Draft for Regional and Park Review

DRAFT

FLOOD MITIGATION STUDY and ENVIRONMENTAL ASSESSMENT

Death Valley Flood Studies
Volume III - Addendum
For Scotty's Castle

DEATH VALLEY NATIONAL MONUMENT
California and Nevada

September 1990

United States Department of the Interior/
National Park Service

CONTENTS

MAPS,CHARTS, AND PHOTOGRAPHS

EXECUTIVE SUMMARY

This document is an addendum to volume III of a three volume study on flood hazard and mitigation at Death Valley National Monument (NPS,1988). That study analyzed the flood hazard and recommended mitigation in those seven areas where people and property are concentrated within flood hazard zones. Of the seven areas with flood hazard in Death Valley, the hazard is most severe at Furnace Creek and Scotty's Castle. However, the importance of maintaining the historic scene at Scotty's Castle caused a delay in the release of this study while other alternatives were developed.

At Scotty's Castle the entire development and surrounding area (1700 acres) was designated as the "Death Valley Scotty Historic District" in 1978. As such the scene within the developed area needs to be maintained as closely as possible to the 1954 period interpreted. Maintaining the appearance of the grounds while adding structural flood mitigation measures is a very difficult task. The purpose of this study is to develop a plan which will provide an adequate level of flood protection for structures and public safety and still maintain the historic scene. This tradeoff involves the assumption of a certain amount of risk to structures and safety which may be unacceptable in other areas in order to preserve the historic scene.

As with the other six areas, the purpose of this addendum is to (1) summarize the findings of volumes I and II on floodplain analysis and structural mitigation; (2) develop nonstructural mitigation alternatives for the area where they are appropriate; (3) evaluate the impacts of the structural and nonstructural mitigation methods for the area; (4) provide a recommended (preferred alternative) plan for the area.

Scotty's Castle is an important historic resource visited by hundreds of thousands of monument visitors each year. The Castle developments are in Grapevine Canyon, which has a 20-30 square mile drainage basin area above the Castle. Several baseline floodplain analyses are presented which aid in identifying the degree of hazard, however, the real flood may deviate from the predicted pattern. A 100-year flood of 8,500 cfs and a Probable Maximum Flood(PMF) of 36,400 cfs were used to calculate the floodplain boundaries at Scotty's Castle. Six historic structures occur within floodplains, three within the 100-year floodplain (gas station, entrance bridge, and a storage building), and three within the PMF (cafe, restroom, and stables). The highest elevation of the 100-year flow will be more than three feet below the floor of the stable, and 1 - 1/2 feet below the cafe, about one third of the parking area will be inundated. The PMF will flow at the rate of 20-feet-per-second, cover all of the parking area, and be about 1/2-foot high on the stable and 2 feet high on the cafe. Such a high speed flow would destroy the cafe. Neither the 100-year or Probable Maximum Floods will affect the castle itself.

The historic entrance bridge,which also contains an apartment occupied by park staff, is susceptible to flooding by 25-year floods or less. Flooding could innundate the apartment and cause erosion of the heavy masonry footings resulting in settling or removal of the structures.

In the water intake area, since the dikes will be breached by the 100-year flood, the collection system would be severely damaged by flows of from 2-1/2 to 4 feet around and over the existing facilities. The chlorinator house would be destroyed.

Five alternatives including no action were considered to mitigate the flood hazard at Scotty's Castle. Several nonstructural flood mitigation measures will be implemented regardless of which alternative is selected including: Information/education so that every visitor is aware of the flood

hazard; signs indicating the flood of record, 100-year flood, and PMF will be posted; and evacuation and emergency preparedness measures will be planned.

No Action

Under no action the water collection system would remain unprotected within the 100 year floodplain. The existing dikes in the water intake area would be breached by the 100 year flood, severely damaging the collection system, destroying the chlorinator house, releasing chlorine into the floodplain. Further downstream in the Castle area the 100 year flood would destroy the gas pumps and probably the entrance bridge structure. Threat to life would occur to occupants of those vehicles parked within the 100 year floodplain and the occupants of the apartment. The probable maximum flood would destroy the water collection system and all vehicles within the parking area as well as five of the six historic structures in the floodplain. Under the no action alternative 270 people during the day and 10 people at night would be in the probable maximum floodplain without structural protection. The potential for substantial loss of life from a flood of this magnitude, would remain unmitigated.

Alternative A (Preferred)

This alternative consists of placing a diversion dike above the parking area, a protective wall around the cafe, an evaluation of several methods to protect the entrance bridge structure, and a warning system. It would cost between $648,000 - 789,000, reduce potential property loss from a 100-year flood from $447,500 to $63,000 and in the event of a PMF from $3,521,500 to $3,409,500 - 2,111,500. The number of people in the probable maximum floodplain without structural protection would be reduced in this alternative.

All six historic structures would be protected to the 100-year flood but subject to damage or destruction from the PMF unless the protective wall was added. The four foot high retaining wall which will protect the cafe will blend in with existing architecture but since the wall was not in place in 1954 it will be a visual impact on the historic scene from that era. The large diversion dike will be hidden by existing vegetation and have no impact on the historic scene. Potentially the most significant visual impacts to the area could come from the four culverts to protect the entrance bridge structure.

The preferred alternative does not provide the optimum amount of protection from flood hazard, nor does it have the least impact on the historic scene, it was selected because it provides a good low cost compromise solution which considers all of these factors. As such it sacrifices some of the maximum safety and property protection advantages that alternative offers but provides a greater degree of protection than any of the other alternatives (particularly if the PMF protective wall is added).

Alternative B

This alternative consists of an underground box culvert to carry the 100-year flood and a warning system. It would cost between $3,145,000 - 3,286,500, eliminate potential property loss from the 100-year flood and reduce loss in the event of a PMF from $3,521,500 to $2,111,500. The number of people in the probable maximum floodplain without structural protection would be the same as the no action alternative.

As in alternative A, all historic structures would be protected to the 100-year flood level but subject to damage or destruction from the PMF unless the protective wall was added. Since the

box culvert would be entirely underground the only visual impacts would be from the entance and exit structures.

Alternative C

This alternative consists of an underground box culvert to carry the flow from the probable maximum flood. It would cost $5,977,000, eliminate potential property loss from the 100-year flood and reduce loss in the event of a PMF from $3,521,500 to $135,500. The number of people in the probable maximum floodplain without structural protection would be reduced to 0.

All historic structures would be protected in this alternative. As in alternative B, since the box culvert would be entirely underground the only visual impacts would be from the entrance and exit structures.

Alternative D

This alternative consists of a corrugated metal pipe to carry the 100-year flood flow. It would cost between $2,944,500 - 3,085,500, eliminate potential property loss from the 100-year flood and reduce loss in the event of a PMF from $3,521,500 to $3,409,500 - 2,111,500. The number of people in the probable maximum floodplain without structural protection would be the same as the no action alternative.

Since the only major difference between this alternative and alternative B is the type of culvert that will be placed underground, impacts on the historic scene and structures will be the same as those discussed in that alternative.

Other Alternatives Considered but Rejected

Alternative E would relocate the parking and picnic areas since they are in the 25-year to 100-year floodplain and are the visitor use facilities in the most hazard.

Alternative F is similar to Alternative E and consists of raising the cafe parking area to protect the parking from the 100-year flood.

Alternative G consists of a concrete channel to carry the 100-year flood.

Alternative H consists of a concrete channel for the probable maximum flood.

Alternative I considered a diversion for a portion of Upper Grapevine Canyon drainage into Tie Canyon drainage.

Alternative J considered a different type of warning system for the Scotty's Castle area.

These alternatives were rejected due to high visual impact on the historic scene (E - H), environmental consequences (I), and design flaws (J).

The document concludes with a series of seven charts that summarize the environmental consequences of all the flood mitigation measures employed at all seven areas.

PREFACE

This document is an addendum to volume III of a three volume study on flood hazard and mitigation at Death Valley National Monument (NPS,1988). The purpose of each of the three volumes is explained in the preface to volume III, which was released to the public in April 1988.

Since every road and most developed areas in the monument are subject to flash flood hazard, the April, 1988 flood mitigation study could not address all of the potentially hazardous areas. Therefore, that study analyzed the flood hazard and recommended mitigation in those seven areas where people and property are concentrated within flood hazard zones. Scotty's Castle was one of those seven areas. However, because of the importance of maintaining the historic scene at Scotty's Castle, additional alternatives needed to be developed. These alternatives were developed in two separate studies entitled Scotty's Castle Supplement and Addendum No. 1. Since a preferred alternative was selected for the remaining six areas, the decision was made to proceed with an environmental assessment for those areas and to prepare a separate environmental assessment dealing with the flood hazard and mitigation problems at Scotty's Castle.

As with the other six areas, the purpose of this addendum is to (1) summarize the findings of volumes I and II on floodplain analysis and structural mitigation (since this is the case not all cross sections shown on the maps are included); (2) develop nonstructural mitigation alternatives for the area where they are appropriate; (3) evaluate the impacts of the structural and nonstructural mitigation methods for the area; (4) provide a recommended (preferred alternative) plan for the area. This environmental analysis for Scotty's Castle, as well as the analysis for the other six areas and the statement of findings (for all seven areas) which will be prepared following approval of this document will serve as the compliance instruments for Executive Order 11988, "Floodplain Management."

This assessment may not serve as the final compliance for all of the proposed projects. Its applicability will depend on the timing of the project, its individual complexity and whether or not natural conditions or design considerations have changed at the time of implementation. Once public review of this document is complete, the National Park Service will make a decision on which projects will require further compliance and which can proceed without additional environmental compliance. This decision will be announced in the "Statement of Findings" (for all seven areas) which will be prepared following the public review of this document.

PURPOSE OF AND NEED FOR THE PLAN

THE FLOOD HAZARD PROBLEM

Death Valley has had a long history of flash flood problems. One of the worst in recent times occurred in 1969 when all roads in and out of the valley were severed by flash flooding and many buildings at Furnace Creek, Scotty's Castle, and Stovepipe Wells suffered damage from mud and sheet flow runoff. As in the 1969 event flash flooding can be widespread across the monument, but more often a severe downpour from a thunderstorm occurs in a localized area. While average annual precipitation on the valley floor is less than 2 inches, precipitation in the adjacent mountains is significantly greater, particularly during the months of July through September the main flash flood season for Death Valley. Cloud bursts in these mountains are the cause of most flash floods. Flash flood flows can become even more dangerous than predicted if they accumulate and move large quantities of debris that can block and redirect flows to areas that seemed safe, or if they erode slopes of an area that had originally appeared to be safe from flood hazard.

Of the seven areas with flood hazard in Death Valley, the hazard is most severe at Furnace Creek and Scotty's Castle. The castle developments within the Grapevine Canyon flash floodplain have suffered damage from sheet and mud flows during heavy rains. A complete listing of the type of development found within the 100-year and probable maximum floodplains is contained in appendix C.

As discussed in the next section both the USGS and the NPS have conducted baseline flood studies for the Scotty's Castle area. Data in subsequent sections is taken from the NPS analysis unless specifically mentioned that it is USGS data. Additional information on these baseline flood studies, the purpose of the volume III study, and nonstructural mitigation are included in pages 3-11 of volume III. These pages are incorporated by reference.

As with the other developed areas in Death Valley the maintenance of scenic quality is one factor used in evaluating the impacts of the flood mitigation proposals. In fact, as discussed in the Preface, the importance of maintaining the historic scene at Scotty's Castle caused a delay in the release of this study while other alternatives were developed.

Preventing or mitigating scenic impacts was an easier task at the other six areas covered in the April, 1988 study. At those areas the primary methods of protection consisted of dikes which could be constructed of natural materials that would blend into the natural terrain above a developed area. In other areas channels were used to divert floodflows through or around existing developed areas. Although these were somewhat visually intrusive, the intrusion was limited by use of natural materials or emplacement in already altered developed areas(of no historical significance).

At Scotty's Castle the situation is different. Here, the entire development and surrounding area (1700 acres) was designated as the "Death Valley Scotty Historic District" in 1978. As such the scene within the developed area needs to be maintained as closely as possible to the period interpreted. That period, for the grounds of Scotty's Castle is 1954. The appearance of the area at that time is well documented in drawings and photographs so it is an achievable goal. Additionally, all the studies on what on the grounds is of significance have not yet been completed, so changes in the grounds need to be kept at a minimum until that is determined.

Maintaining the appearance of the grounds while adding structural flood mitigation measures is a very difficult task. Particularly, since the canyon is fairly narrow at the castle location and the flood hazard is one of the most severe in the monument. Structural mitigation measures which would be perfectly acceptable in other developed areas such as Cow Creek and Stovepipe Wells are visually unacceptable here at this site.

The problem then becomes one of providing an adequate level of flood protection for structures and public safety while still maintaining the historic scene. This tradeoff involves the assumption of a certain amount of risk to structures and safety which may not be as acceptable in other areas in order to preserve the historic scene. The purpose of this study is to develop a plan which considers both of these factors.

BASELINE FLOOD STUDIES

In order to better understand the extent of the flood hazard problem at Death Valley, the NPS contracted with the U.S. Geological Survey (USGS) to study potential hazards from flood flows at Scotty's Castle in ~~1983~~. That study evaluated what conditions would be like during flash floods, and provided cross sections and plan view maps of the flood flows for 25, 50, and 100 year floods. Such baseline data was essential before flood mitigation studies could begin. The cross sections also showed the maximum experience flood (Qme), which is the largest flood that could realistically be expected for that drainage based on an equation that describes an envelope curve which includes the maximum floods experienced in the deserts of the Basin and Range province.

Because there were other areas not studied by USGS that needed baseline flood studies to determine the extent of flood hazard, the National Park Service developed a complete and consistent set of flood baseline studies for all the developed areas of concern These studies have been compiled in volume I, but the most pertinent data for Scotty's Castle is summarized in this document for easy reference. These analyses are comparable to those done by USGS, except that instead of calculating maximum extreme (Qme) flood, NPS calculated probable maximum flood (PMF, also abbreviated as PMP throughout the text). These are two different methods of calculating the largest flood that can be expected within the drainage. They would rarely produce exactly the same results, but both methods estimate large floods of similar magnitude that represent the largest possible flood that would be likely to occur in a given drainage. The NPS calculations for flash-flood flow take into consideration the rate of precipitation, size of drainage, time of flood concentration, length of drainage, change in elevation within the drainage, duration of precipitation, and amount of runoff after absorption in the soil. Specific methodology is described in the ~~April~~ March, 1988 study. As noted in the previous section, data in subsequent sections is taken from the NPS analysis unless specifically mentioned that it is USGS data.

It must be clearly understood that any of the seemingly well defined and precisely calculated flood levels and flood plains are only estimates of the flood conditions. The real flood levels, locations, and impacts resulting from a flood may be unpredictable. This extreme uncertainty results for several reasons as discussed in the section entitled Baseline Flood Studies of the April, 1988 study. The subsequent baseline floodplain analyses must be interpreted in light of these uncertainties. The major point to keep in mind is that although the following flood plain analyses aid in identifying the degree of hazard, the real flood may deviate from the predicted pattern.

AFFECTED ENVIRONMENT

Pages 15-27 of Volume III give a general overview of the affected environment within the monument. Additional details are given under the "Flood Hazard" section for each area. Environmental components selected for impact analysis are discussed in the first paragraph of the "Environmental Consequences" section for each area. The same format will be followed for this addendum and pages 15-27 of volume III are incorporated by reference.

ALTERNATIVES AND ENVIRONMENTAL CONSEQUENCES

INTRODUCTION

This section of the report contains alternative flood mitigation plans for the area. The discussion is divided into: a description of the flood hazard; the mitigation alternatives, including a preferred alternative, which have been developed to mitigate the flood hazard; and an evaluation of the environmental consequences of each of the alternatives.

Two points should be noted while reading through the discussions:

1) For consistency with the Volume III document, wherever cost figures are given in this document they are class "c" estimates (based on similar facilities in other NPS areas) for 1988 "gross" construction costs, rounded to the nearest $500.

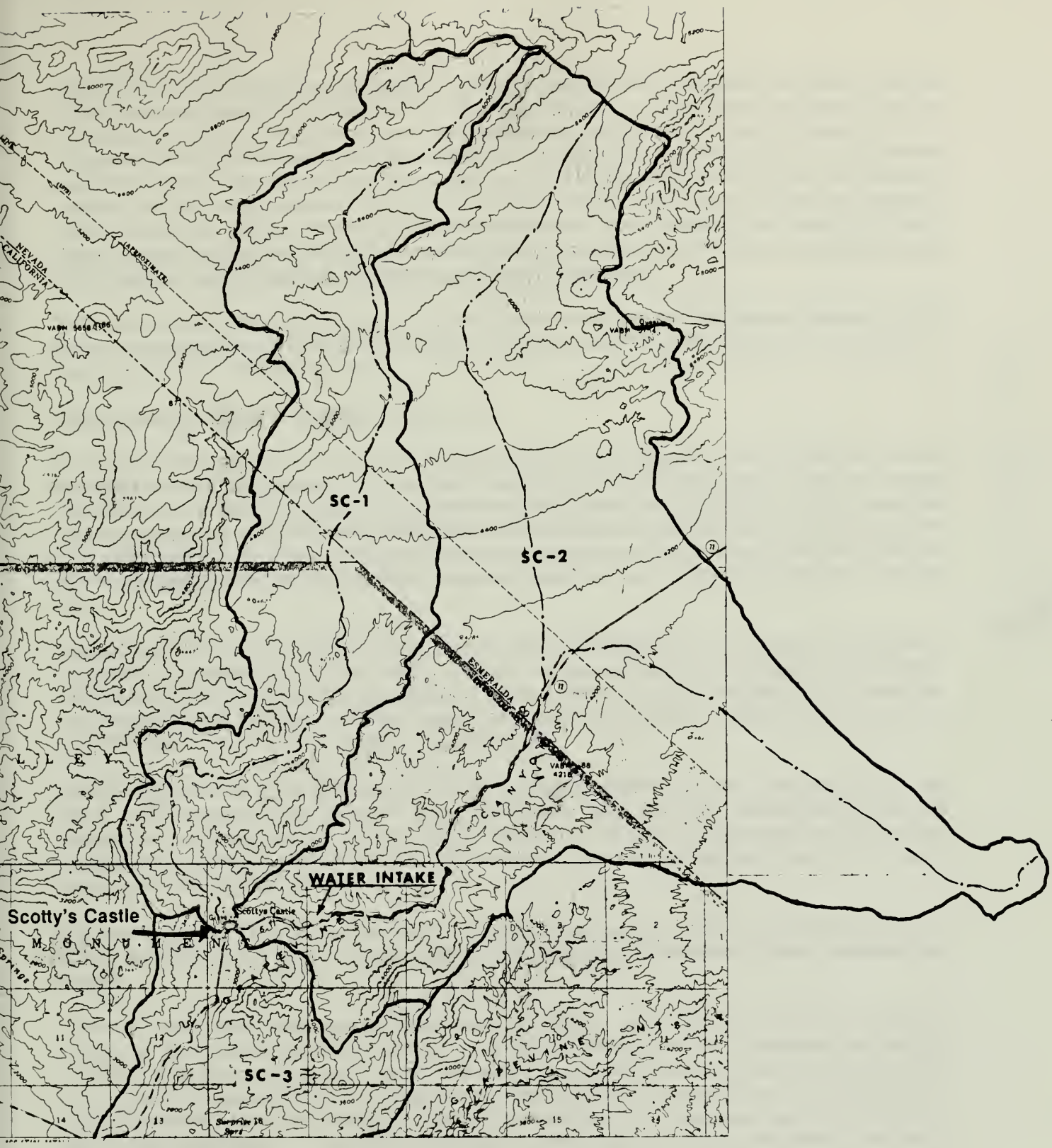
2) In the environmental consequences section, several tables list developments in the 100-year and probable maximum floodplains (PMF). These structures in the floodplain might be damaged or destroyed if a flood occurred. Structures listed in the 100-year floodplain are also in the PMF. However, to avoid repetition, only structures that are in the PMF but not the 100-year floodplain are listed in the PMF column.

FLOOD HAZARD

Scotty's Castle is an important historic resource visited by hundreds of thousands of monument visitors each year. Regular tours of the castle are offered year-round and are so popular that during peak visitation times (holidays and weekends), tours are shortened to accommodate more visitors. There are also NPS and concession support facilities. The NPS facilities include apartments for employee housing, a picnic area, and a maintenance area. TWA Services, the concessioner, provides gasoline, souvenirs, and a cafe. A picnic area and ticket booth are also provided. No public lodging is available.

The Castle developments are in Grapevine Canyon, which has a 20-30 square mile drainage basin area above the Castle. Where the lower portions of the Castle developments are in the Grapevine Canyon flash floodplain, most of the buildings suffer damage from sheet flow and mud flows off adjacent hillsides during heavy rains. This localized flow has caused damage to the historic structures in recent years.

The areas of concern include three drainage basins shown on the map (page 9) as SC-1, Tie Canyon; SC-2, upper Grapevine Canyon area; and SC-3, lower Grapevine Canyon. Scotty's Castle is located at the mouth of the upper Grapevine Canyon drainage area. Flood levels for that drainage area will also be calculated for the water intake area for Scotty's Castle which is located about one mile above the castle.



SCOTTY'S CASTLE AREA

DRAINAGE BASINS

DEATH VALLEY NATIONAL MONUMENT

UNITED STATES DEPARTMENT OF INTERIOR/NATIONAL PARK SERVICE

N

SCALE 3/4":1 MILE

143	40,103
DSC	AUG 89

Field observation indicates that the Grapevine Ranger Station and housing area are located outside of the floodplain south of the mouth of lower Grapevine Canyon. Flooding in this area occurs as a result of overflow from the main Grapevine Drainage across the highway into the Grapevine area. This problem can be corrected by minor redesign of the highway at several critical sections below Scotty's Castle. Tie canyon was excluded from further study because of the deteriorating condition of the gravel separator and since the canyon was not used for anything but transitory visitor use such as hiking. Protection can be accomplished here by signing the hazard in the area. Recently the area has been used for overflow parking and this use will need to be relocated or additional structural protection methods for the area investigated.

The greatest flood hazard to the Scotty's Castle development occurs from floods originating in the Upper Grapevine Canyon drainage basin (SC-2). The hazard in that drainage basin is discussed in more detail in the following section.

Upper Grapevine Canyon Drainage Basin (SC-2)

In upper Grapevine Canyon the 100-year flow of 8,500 cfs compares to the 12,100 cfs flow as determined in the USGS study. The probable maximum flood flow is 36,400 cfs for this study; whereas, the maximum experience flow from the USGS study was 93,700 cfs. The reason for these discrepancies was discussed under Baseline Flood Studies in the Purpose of and Need for the Plan section of this document. Flooding of the highway will occur in several locations by smaller flows than the 25-year flood, especially in locations where the road covers nearly the entire canyon floor.

Castle Area. A 100-year flood of 8,500 cfs and a PMF of 36,400 cfs were used to calculate the floodplain boundaries (page 12) at Scotty's Castle. As shown in section 2B (page 13), the highest elevation of the 100-year flow(d100) will be more than three feet below the floor of the stable, and the PMF(dPM) will be about 1/2-foot high on the face of the stable. Neither the 100-year or Probable Maximum floods will affect the castle itself.

As shown in sections 2C and 2D (pages 14,15), the highest elevation of the 100-year flow will be about 1-1/2 feet below the cafe and about 50-75 feet from the cafe. About one-third of the parking area will be inundated. A PMF flood would flow at the rate of 20-feet-per-second(fps) and cover all the parking area below the cafe and be about 2 feet high on the cafe. Such a high speed flow would destroy the cafe.

The auto gas pumps in the lower portion of the castle parking lot would be inundated by 25-year floods or larger. This is an extremely dangerous location for hazardous liquids handling and storage.

"The most significant flood peak in recent years occurred in July 1976, near Scotty's Castle, as a result of an intense convective storm in the Grapevine Mountains. An estimated discharge of 2,900 cfs was calculated based on depth and width observations made by Park Service personnel . . . . This flood approximates the computed 25-year recurrence interval flood . . . of 3,500 cfs. It is interesting to note that during the July 1976 flood, an N.P.S. observer reported no trace of rain at Scotty's Castle. . . . This flood cut a narrow, deep channel through the center of the picnic area at the castle" (oral comm. , N.P.S. personnel 1983), rather than ponding upstream of the bridge opening (as calculated using stable cross sections). Based on this evidence of channel instability, the theoretical elevations presented in this study should be used (only) as a guide when evaluating potential flood hazards.

The floodplain boundary map (page 12) was prepared for the castle area by using procedures for computing flows through bridge openings. This analysis indicates that the flow would not entirely pass through the bridge opening for a flood with a recurrence interval of 50 years. Over 50

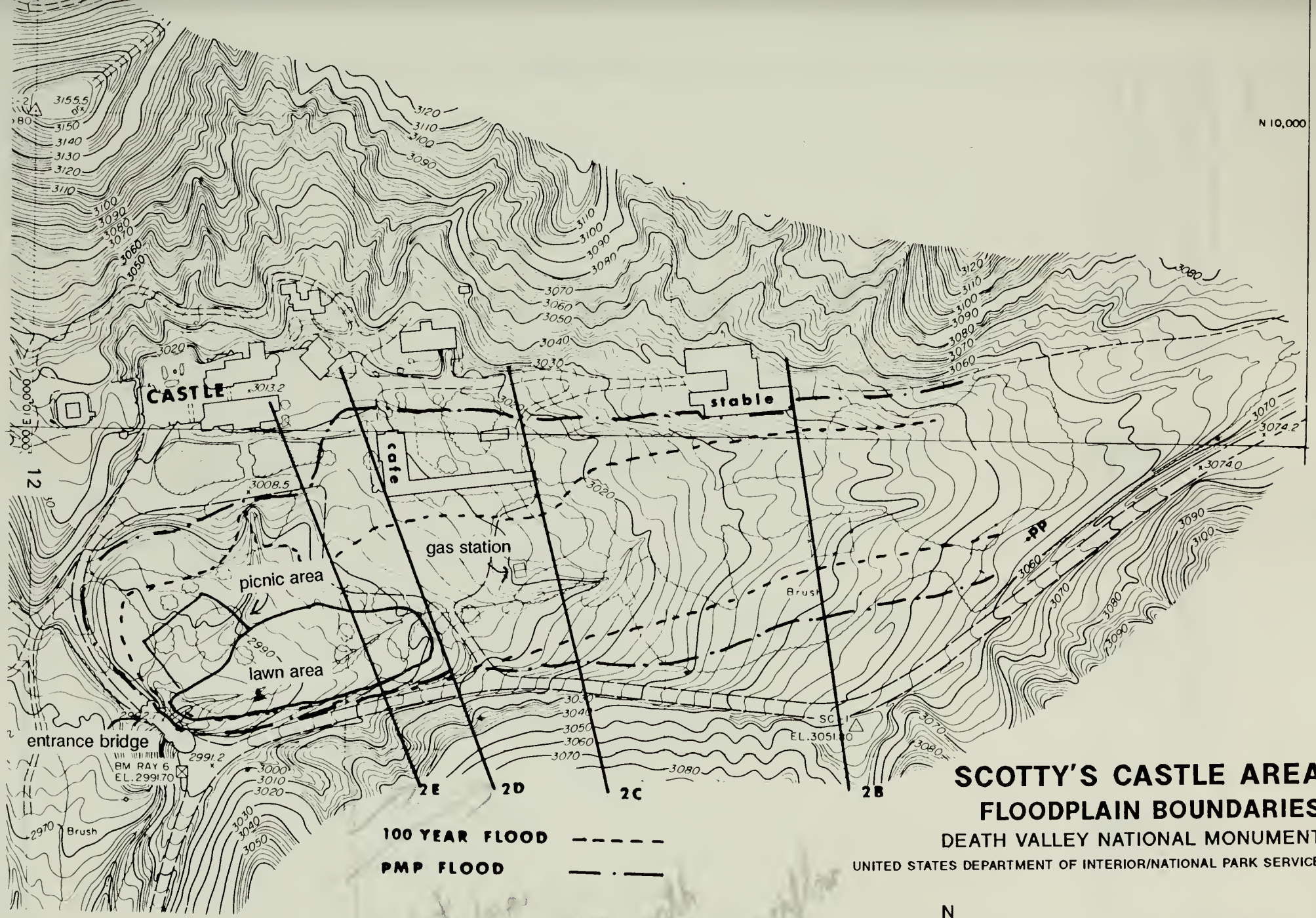
percent of the flow would go over the bridge and approach embankments at a discharge of 5,000 cfs, which is 1,090 cfs less than the 50-year event." (USGS, 1983).

Water Intake Area. A 100-year flow of 8,500 cfs and a PMF flow of 36,400 cfs were also used to determine the floodplain boundaries (page 16) for the water intake area about one mile above Scotty's Castle. As shown in sections 2A.2 and 2A.3 (pages 17,18) the 100-year flood would overflow the existing protective dike by 1/2 to 2 feet. This flow would flood the spring box and channel, and chlorinator house.

Since the dikes will be breached by the 100-year flood, the collection system would be severely damaged by flows of from 2-1/2 to 4 feet around and over the existing facilities. The chlorinator house would be destroyed. Chlorine is a substance that should not be stored in the floodplain in large volumes.

Combined Flows from SC-1, SC-2, SC-3

The combined flows from upper Grapevine Canyon, Tie Canyon, and lower Grapevine Canyon are 11,500 cfs for the 100-year flood and 55,200 cfs for the PMF. The roadway in lower Grapevine Canyon will be covered by up to 4 feet of flood water during a 100-year runoff and by up to 12 feet during PMF runoff at locations where the roadway is on or near the canyon floor. Overflow from these floods could enter the NPS Grapevine development.



SCOTTY'S CASTLE AREA

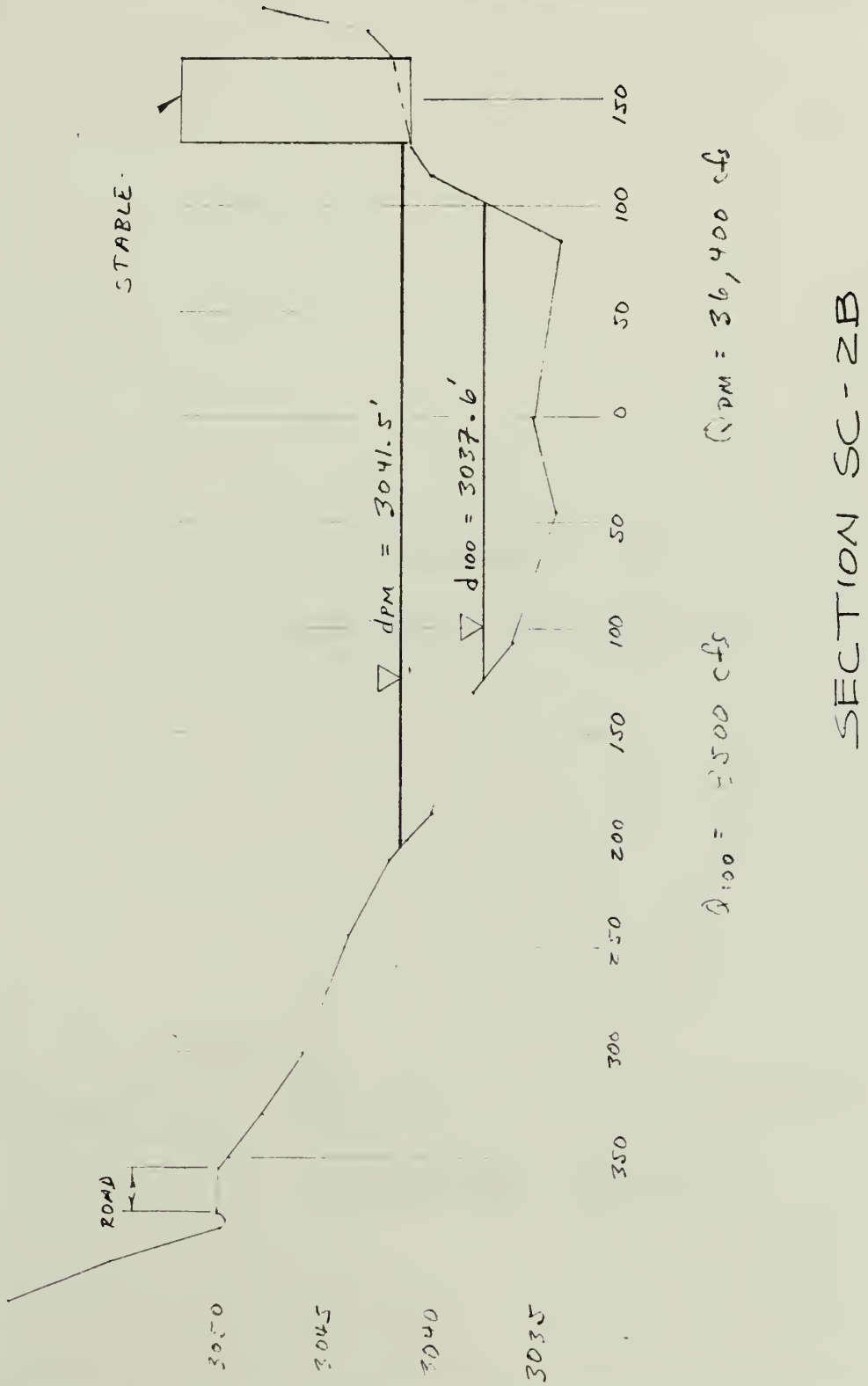
FLOODPLAIN BOUNDARIES

DEATH VALLEY NATIONAL MONUMENT

UNITED STATES DEPARTMENT OF INTERIOR/NATIONAL PARK SERVICE

FORM D S C - 44

Park DEATH VALLEY NM	NATIONAL PARK SERVICE DENVER SERVICE CENTER		Sheet 9
Area SCOTTY'S CASTLE			of
Project CASTLE AREA	By R. G.	Checked	Pkg.
Feature SECTION SC-2B	Date 6/29/84	Date	Account



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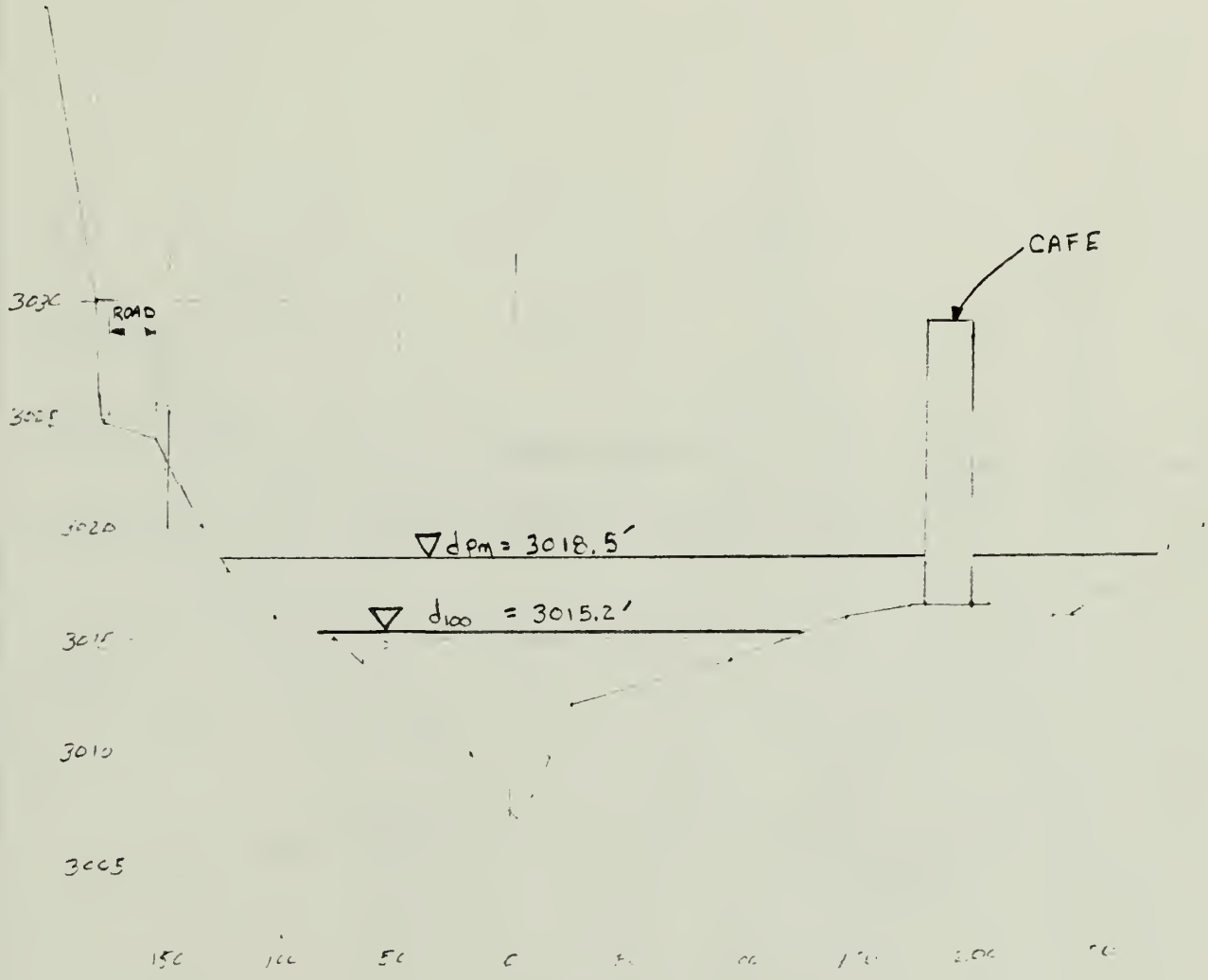
FORM D S C - 44

Park	DEATH VALLEY NM	NATIONAL PARK SERVICE DENVER SERVICE CENTER		Sheet 10
Area	SCOTTY'S CASTLE			of
Project	CASTLE AREA	By	Checked	Pkg.
Feature	SECTION SC-2C	Date	Date	Account



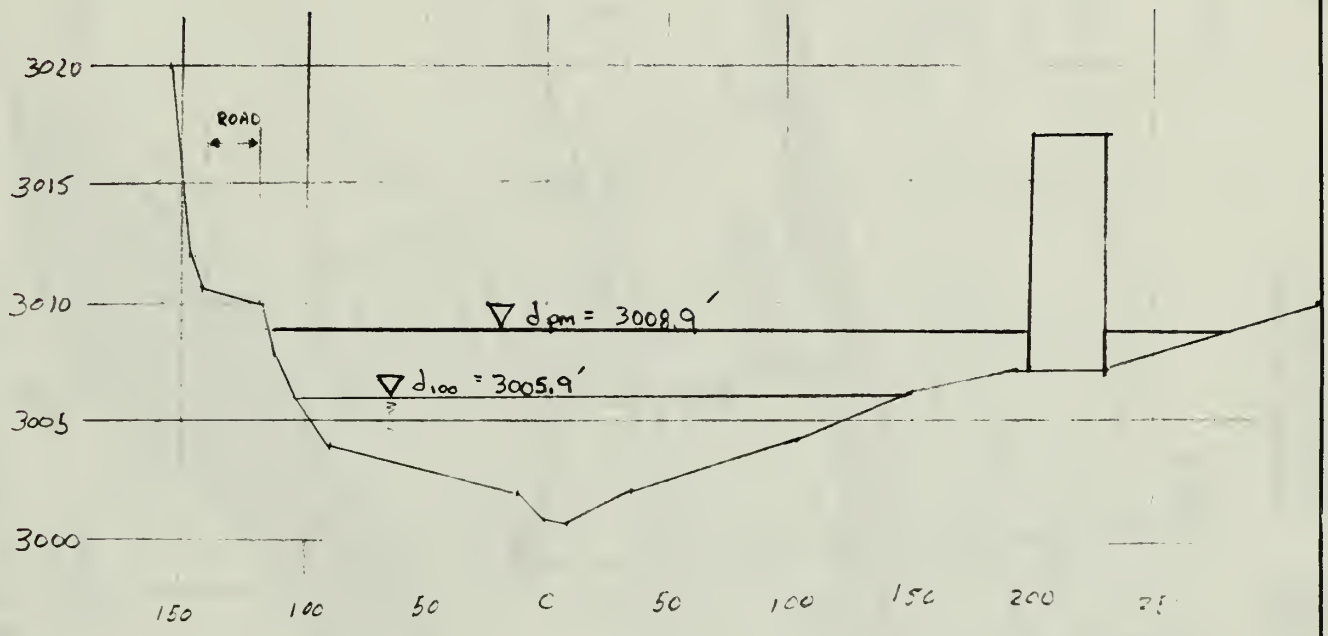
Q_{100} = 850 cfs Q_{pm} = 36,400 cfs

SECTION SC-2C

•U.S. GPO: 1984-778-378

FORM D S C - 44

Park	DEATH VALLEY NM	NATIONAL PARK SERVICE DENVER SERVICE CENTER		Sheet 11
Area	SCOTTY'S CASTLE			of
Project	CASTLE AREA	By	Checked	Pkg.
Feature	SECTION SC-2D	Date	Date	Account



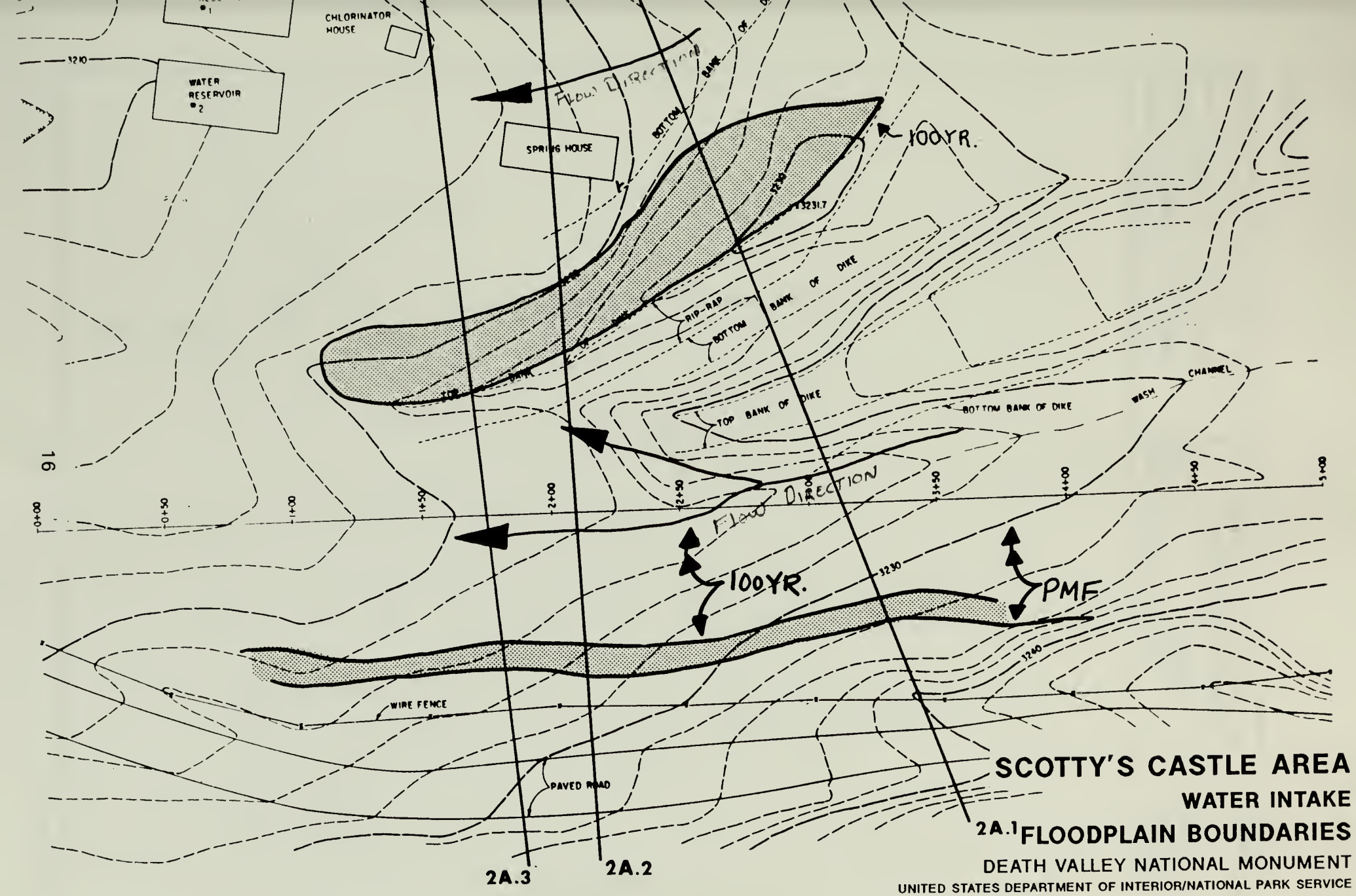
$Q_{100} = 8500$ cfs

$Q_{pm} = 36,400$ cfs

$V = 20$ fps

SECTION SC-2D

•U.S. GPO: 1984-778-378



SCOTTY'S CASTLE AREA
WATER INTAKE
FLOODPLAIN BOUNDARIES
DEATH VALLEY NATIONAL MONUMENT
UNITED STATES DEPARTMENT OF INTERIOR/NATIONAL PARK SERVICE

indicates area above 100 year floodplain within PMF

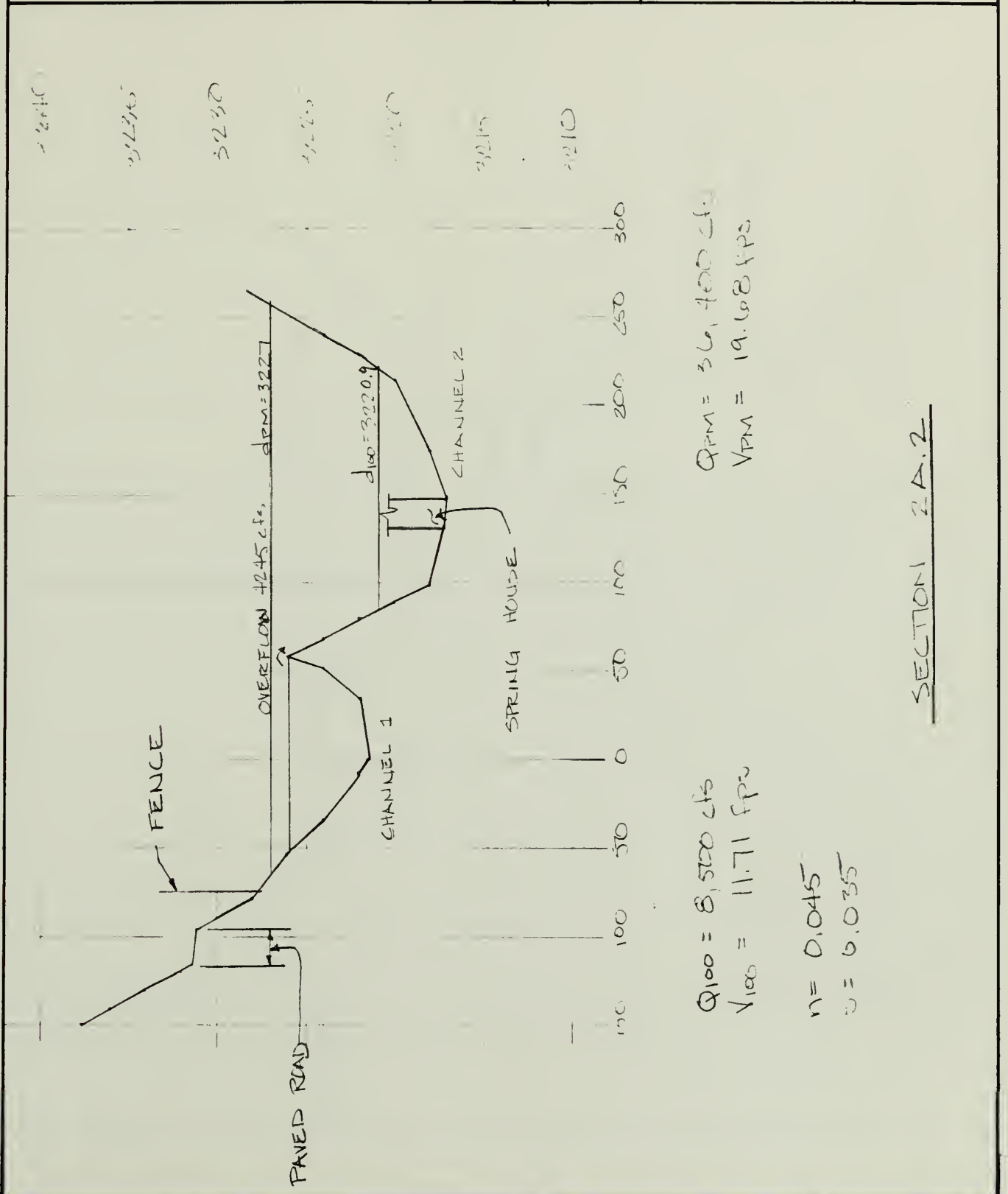
N

SCALE 1":50'

143	40,106
DSC	AUG 89

FORM D S C - 44

Park DEATH VALLEY NM	NATIONAL PARK SERVICE DENVER SERVICE CENTER			Sheet 15
Area SCOTTY'S CASTLE				of
Project WATER INTAKE	By T. G.		Checked	Pkg.
Feature SECTION 2A.2	Date 4/8/85		Date	Account



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FORM D S C - 44

Park DEATH VALLEY NM	NATIONAL PARK SERVICE DENVER SERVICE CENTER			Sheet 16
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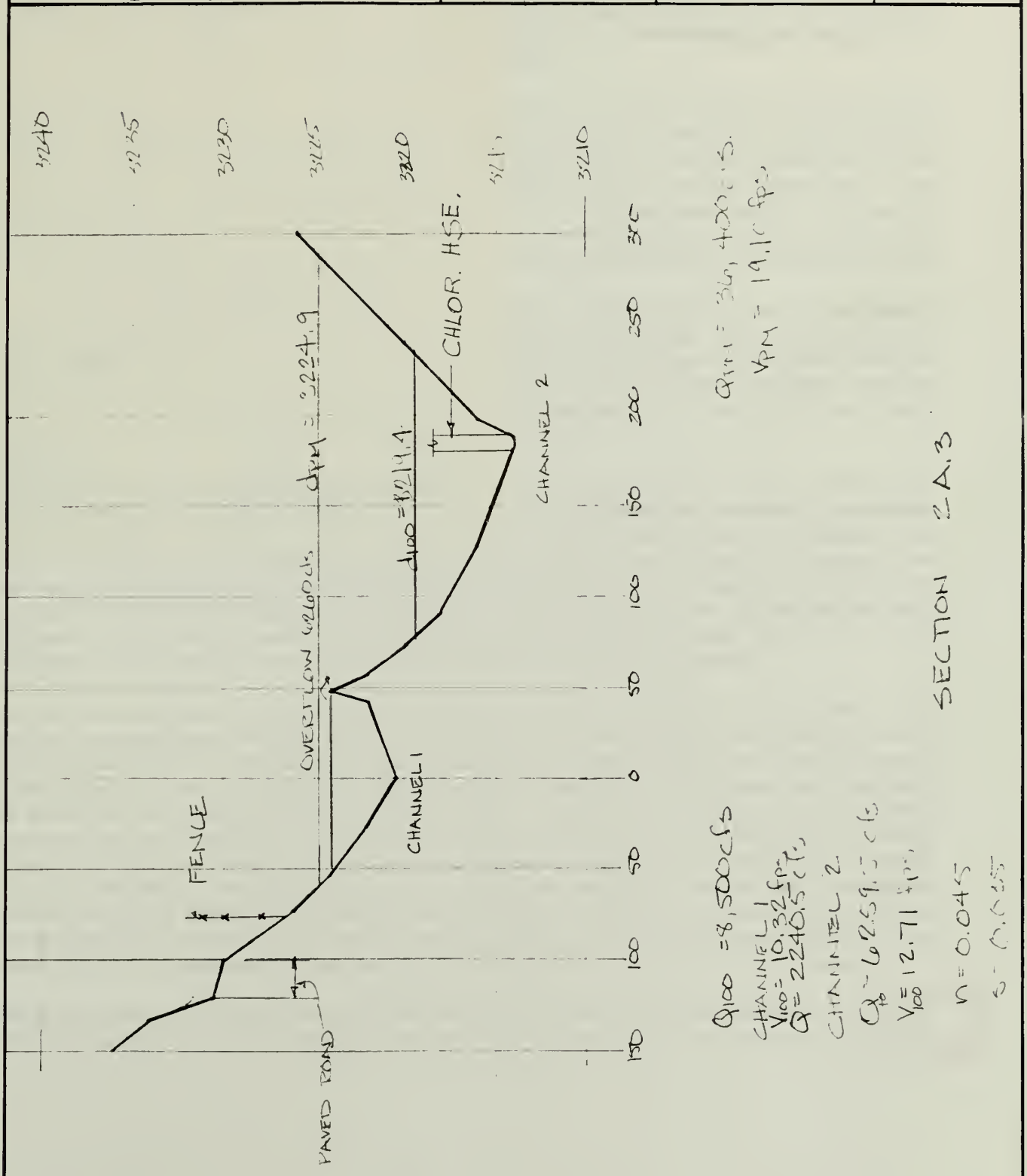
Project WATER INTAKE	By T.G.		Checked	Pkg.
Feature SECTION 2A.3	Date 11/8/85		Date	Account



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MITIGATION ALTERNATIVES

Several nonstructural flood mitigation measures should be implemented irrespective of what other mitigation measures are taken. Information/education should be provided so that every visitor to the area is aware of the flood hazard area, where safe areas are located, and what they should do if a flood warning is sounded. This information should be provided immediately upon entering the area by eye-catching waysides in the parking lot and at bus unloading areas. Other locations for such a wayside would be near the ticket office, since visitors frequently linger in this area waiting for castle tours; and the picnic area, since it is in the hazard zone. The construction costs for five wayside interpretive signs would be approximately $1,500.

A leaflet describing the hazard at Scotty's Castle and what to do if the warning is sounded should be given to each person purchasing castle tour tickets. The castle tour tickets could be redesigned to have that information printed directly on them. A brief mention of the hazard and what to do during an evacuation could be added to each of the castle interpretive tours. Information on the hazards at Scotty's Castle should also be included in a monument-wide leaflet. This leaflet, proposed in the April, 1988 study would be available at numerous locations and explain the flood hazard throughout the monument and make special mention of the hazard at each developed area.

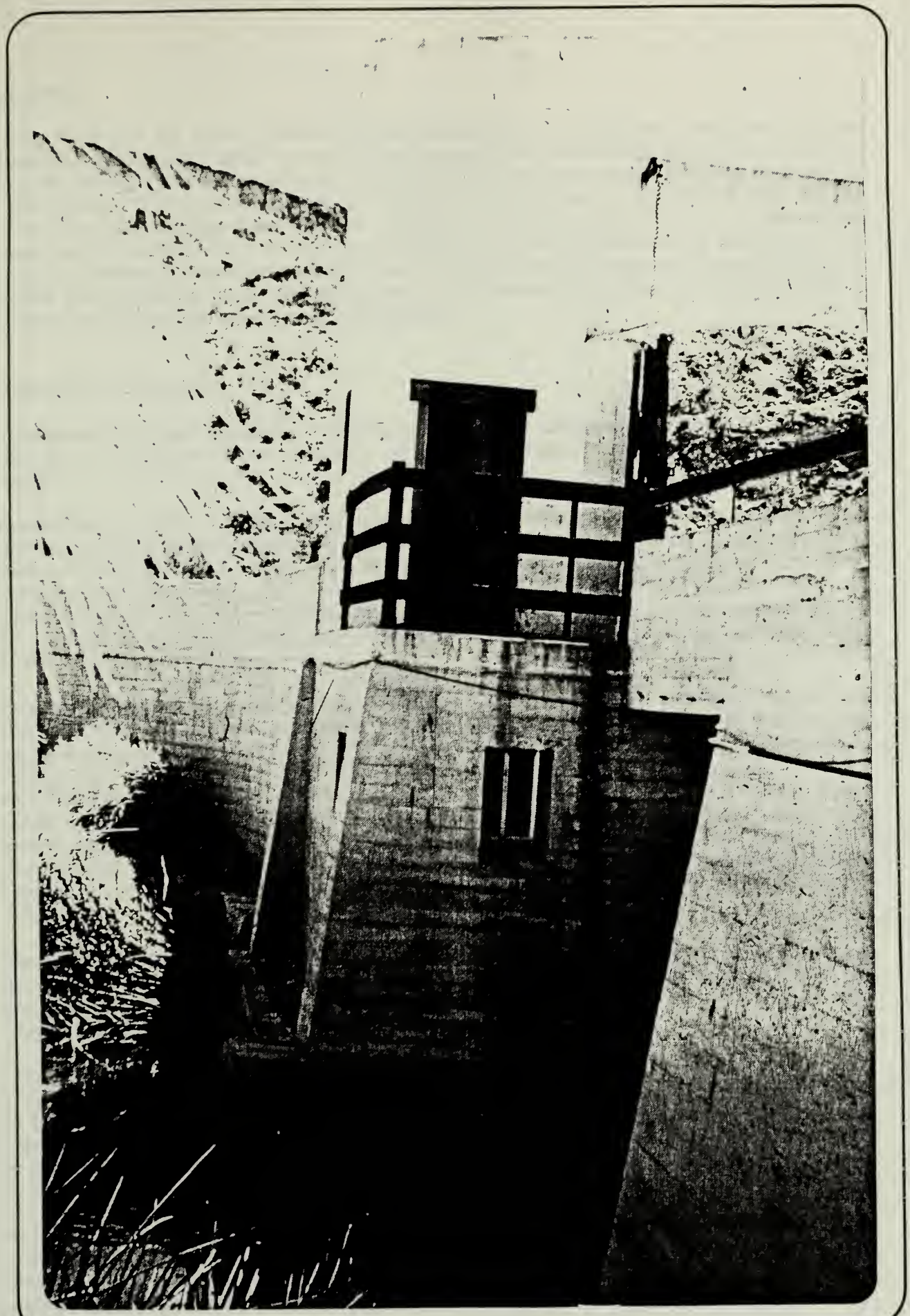
To comply with NPS guidelines on floodplain management, signs indicating the flood of record, 100-year flood, and PMF must be posted around the area and on buildings. These will help visitors visualize where hazardous and safe areas are located, and will reinforce the waysides' message that there are hazardous areas. Depending on the location of the waysides, the signs might be built on the waysides and the message developed to enhance both. The costs for six such signs would be approximately $2,000.

Evacuation and emergency preparedness measures will have to be planned. Flood safe areas will be identified where people can be sent during an evacuation. Perhaps the courtyard by the castle gates would be an easily identifiable area where large numbers of people could be managed. The chain of command and who is responsible for what actions must be identified. For example, the road near the mouth of Grapevine Canyon must be blockaded to prevent additional visitors from entering the area, and the parking and picnic area must be checked to be sure all visitors have evacuated. The need for emergency food and water, medical supplies, and earth moving equipment must be defined and those items provided for post-flood operations.

The historic entrance to the castle is over a bridge that crosses Grapevine Canyon wash. That location is susceptible to flooding by 25-year floods or less. As shown in photographs 1 and 2 some windows in the apartment are below the height of the bridge. It appears certain that under present conditions that occurrence of a 100-year flood, or perhaps even a 50-year flood, will break the windows and flood the interior of the apartment. Other flooding concerns include possible erosion at the foot of the heavy masonry on each side of the channel which might cause settling or even removal of the structures. Such erosional forces are directly proportional to the stage and velocity of the flow. Concerns also include the structural integrity of the low dam immediately downstream of the bridge. The failure of the dam during flooding would increase the stream gradient upstream, which in turn would increase velocities and greatly enhance erosion. The people living in the apartment should be relocated immediately due to the extreme hazard.

The storage tanks for the gas pumps should be relocated above the PMF floodplain, as should chlorine storage in the water intake area. Relocation of these facilities would cost about $75,500.

Photograph No. 1
Scotty's Castle Entrance Bridge
(From East. Apartment on Left)



Photograph No. 2
Bridge Apartment: Northeast Corner

No Action

Under no action the water collection system would remain unprotected within the 100 year floodplain. The existing dikes in the water intake area would be breached by the 100 year flood, severely damaging the collection system, destroying the chlorinator house, releasing chlorine into the floodplain. Further downstream in the Castle area the 100 year flood would destroy the gas pumps and probably the entrance bridge structure. Threat to life would occur to occupants of those vehicles parked within the 100 year floodplain and the occupants of the apartment. The probable maximum flood would destroy the water collection system, the cafe, the gas pumps, the bridge, and all vehicles within the parking area. The potential for substantial loss of life from a flood of this magnitude, would remain unmitigated.

Alternative A (Preferred)

This alternative consists of placing a diversion dike above the parking area, a protective wall around the cafe, an evaluation of several methods to protect the entrance bridge structure, and a warning system.

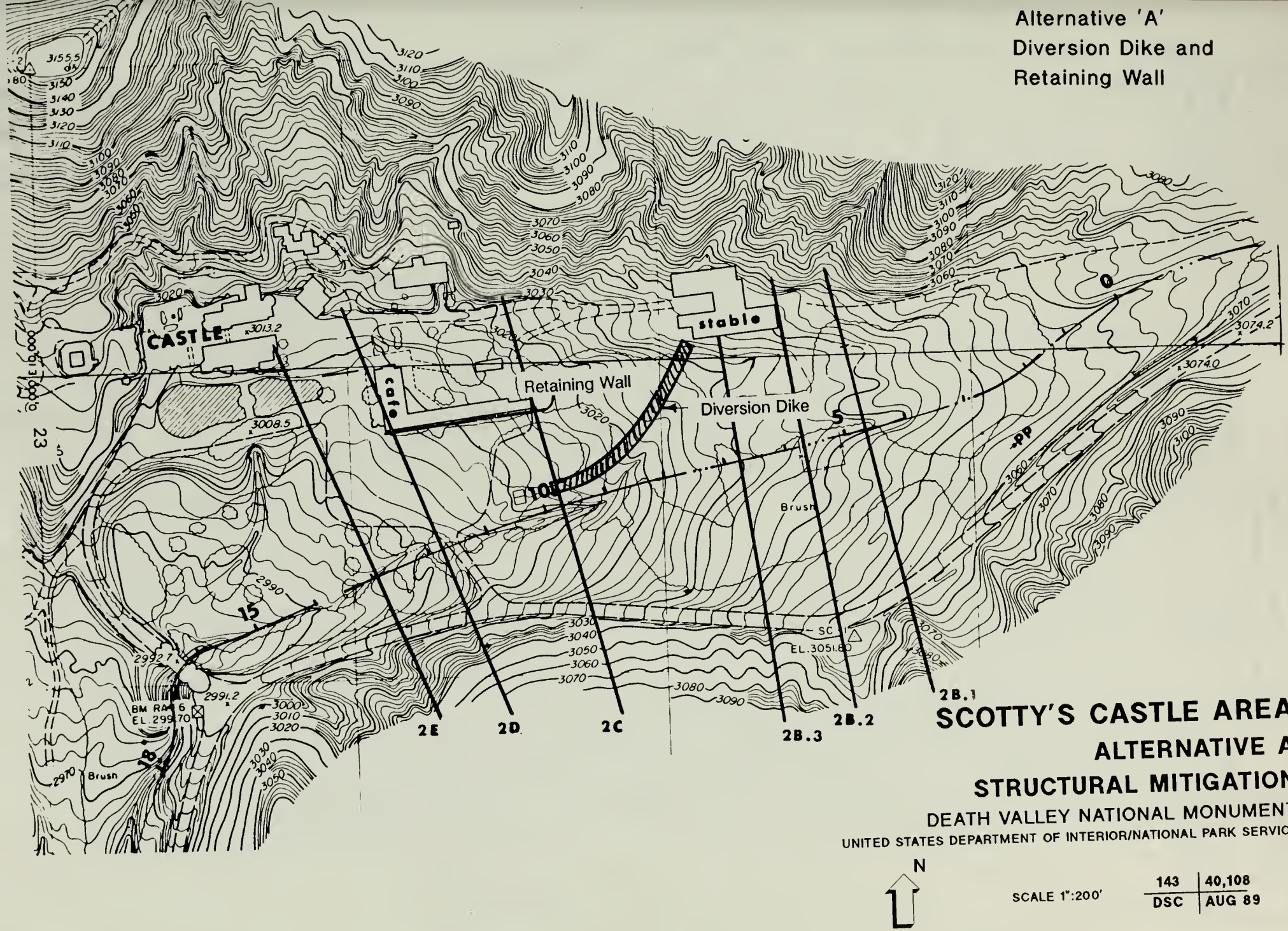
Castle Area. The graphic entitled Alternative A, Structural Mitigation, shows the location of the diversion dike and protective retaining wall around the cafe building. Page 24 depicts the dike at section 2c where it is 8 feet high at the center, 12 feet wide at the top, and has (2:1) slopes on the sides lined with gabions and filter fabric to prevent erosion of the face of the dike. The total width of the dike varies from about 24 feet near the stable to about 50 feet approaching section 2c. The dike as designed and as shown on the graphic is 350 feet long and ends near the location of the automobile in Photograph No. 3.

This dike will contain the calculated flow of a probable maximum flood. A dike to contain only the 100-year flood was not considered since it could not adequately contain larger flash floods and would not protect the parking area from damage. However, the turbulent flow generated by a severe flood will cause waves to spill over the dike. Nevertheless, the dike appears to serve an important function. The combination of the trees upstream of the dike in conjunction with the dike should take the brunt of a flash flood of the 50-year to probable-maximum size and eliminate or greatly reduce the danger to people in the parking and cafe areas. The 100-year flood will still inundate the same amount of parking area but without the flow velocity and debris hazards associated with a flash flood danger. A probable maximum flood would still damage or destroy the cafe without further protection.

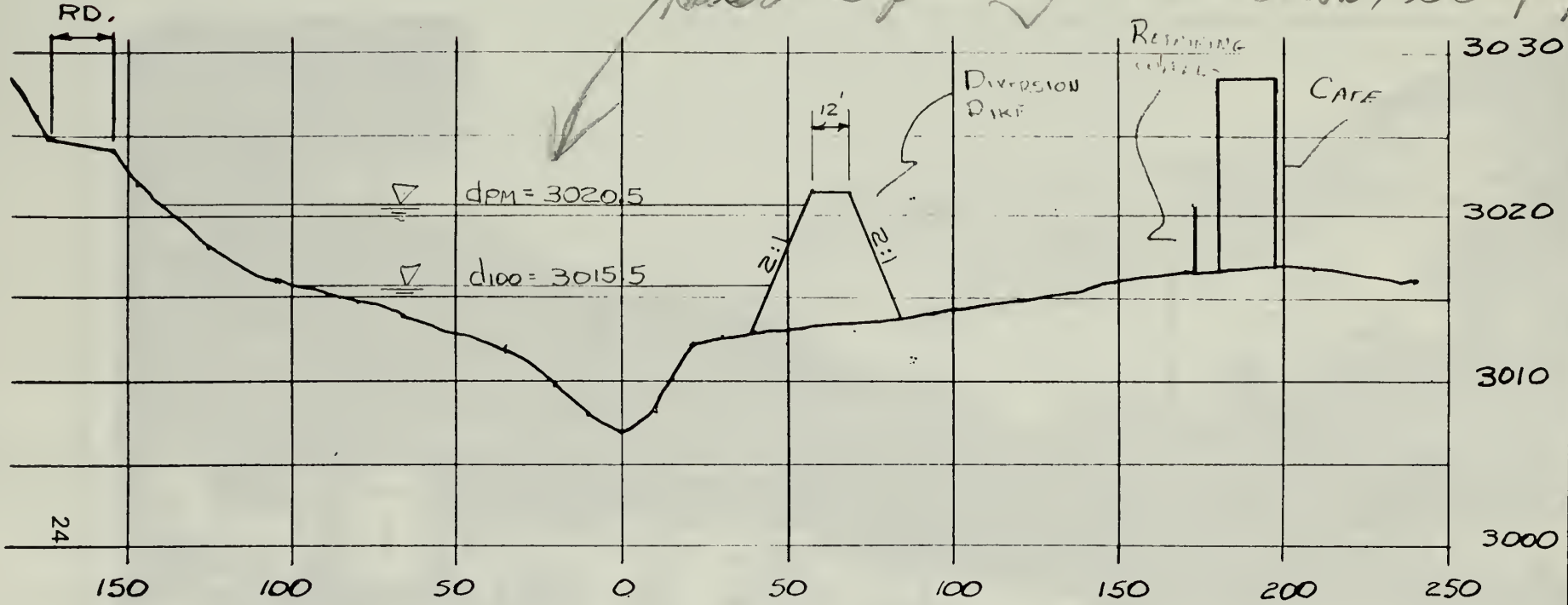
Photograph No. 4 shows the south side of the cafe and cafe apartments. A wall four feet high and 300 feet long as shown on pages 27 and 28 would protect the cafe and apartments and hide the profusion of utility piping and conduits. The wall could have a stucco finish and could even be capped with clay tile to match the roof of the cafe building.

The estimated costs as tabulated on page 29 are $164,500 for the dike and $91,000 for the cafe protective wall. To provide protection from the PMF the wall could be extended another 100 feet to the east. This level of protection would be necessary only if there are sleeping quarters in the cafe during flood season for life safety, or if the cafe is to be fully protected from damage by floods in excess of the 100-year flow. The total length of this wall would be 400 feet and total cost $116,500.

As indicated from the calculations on page 30, a large concrete channel 18 feet wide, 9 feet deep, and about 200 feet long (to accommodate a flared inlet structure) would be required to direct the flow through the bridge structure. This possibility was not estimated since the expanse of concrete would be an unacceptable impact on the historic scene.


Alternative 'A'
Diversion Dike and
Retaining Wall
CASTLE
3013.2
cafe
stable
Retaining Wall
Diversion Dike
3008.5
3074.2
3074.0
Brush
SC
EL. 3051.80
2991.2
BM RA 6
EL. 2997.70
2E
2D
2C
2B.3
2B.2
2B.1
SCOTTY'S CASTLE AREA
ALTERNATIVE A
STRUCTURAL MITIGATION
DEATH VALLEY NATIONAL MONUMENT
UNITED STATES DEPARTMENT OF INTERIOR/NATIONAL PARK SERVICE
N
SCALE 1":200'
143 | 40,108
DSC | AUG 89

raised 2 feet by construction, see page 14

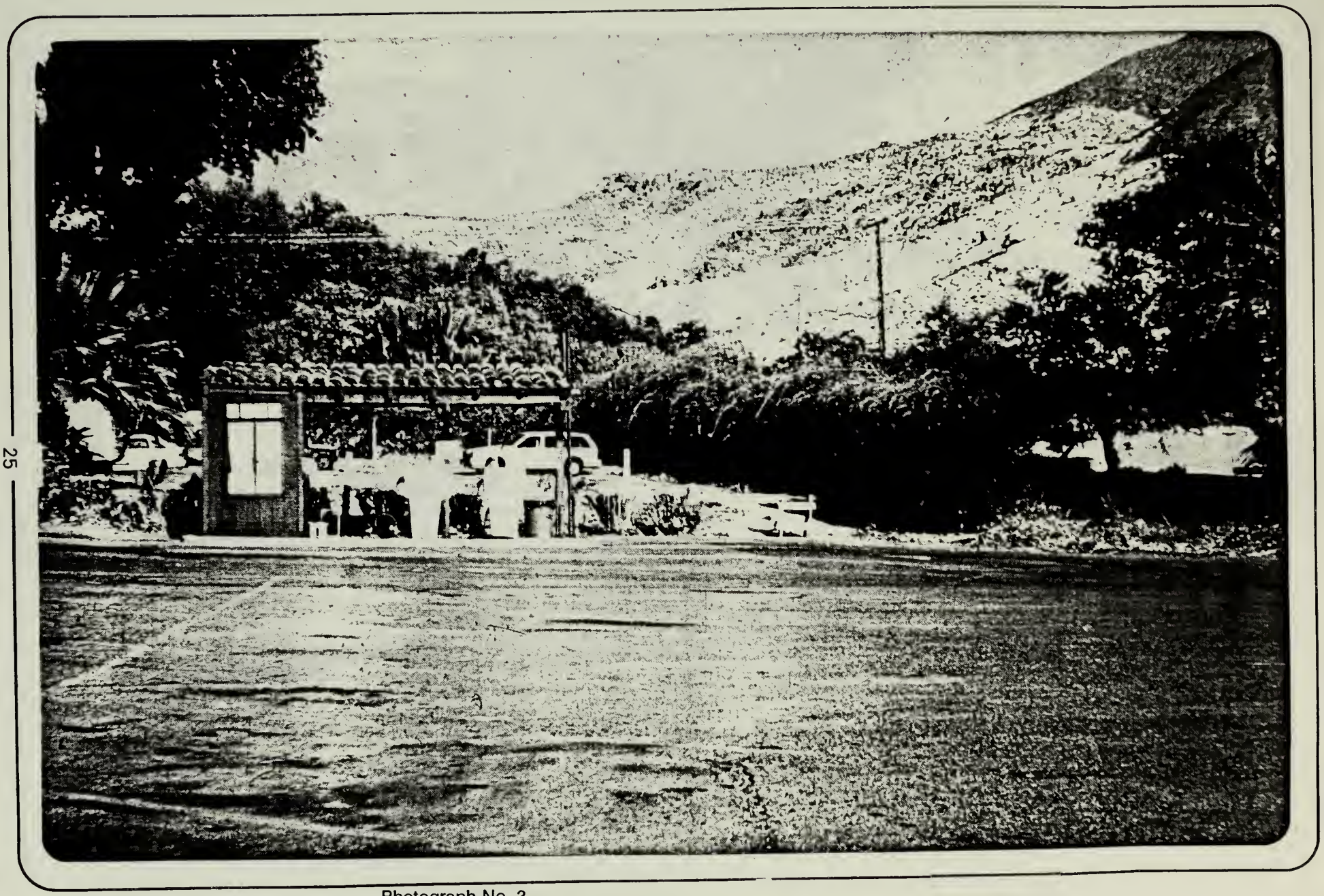


SCOTTY'S CASTLE - 2C

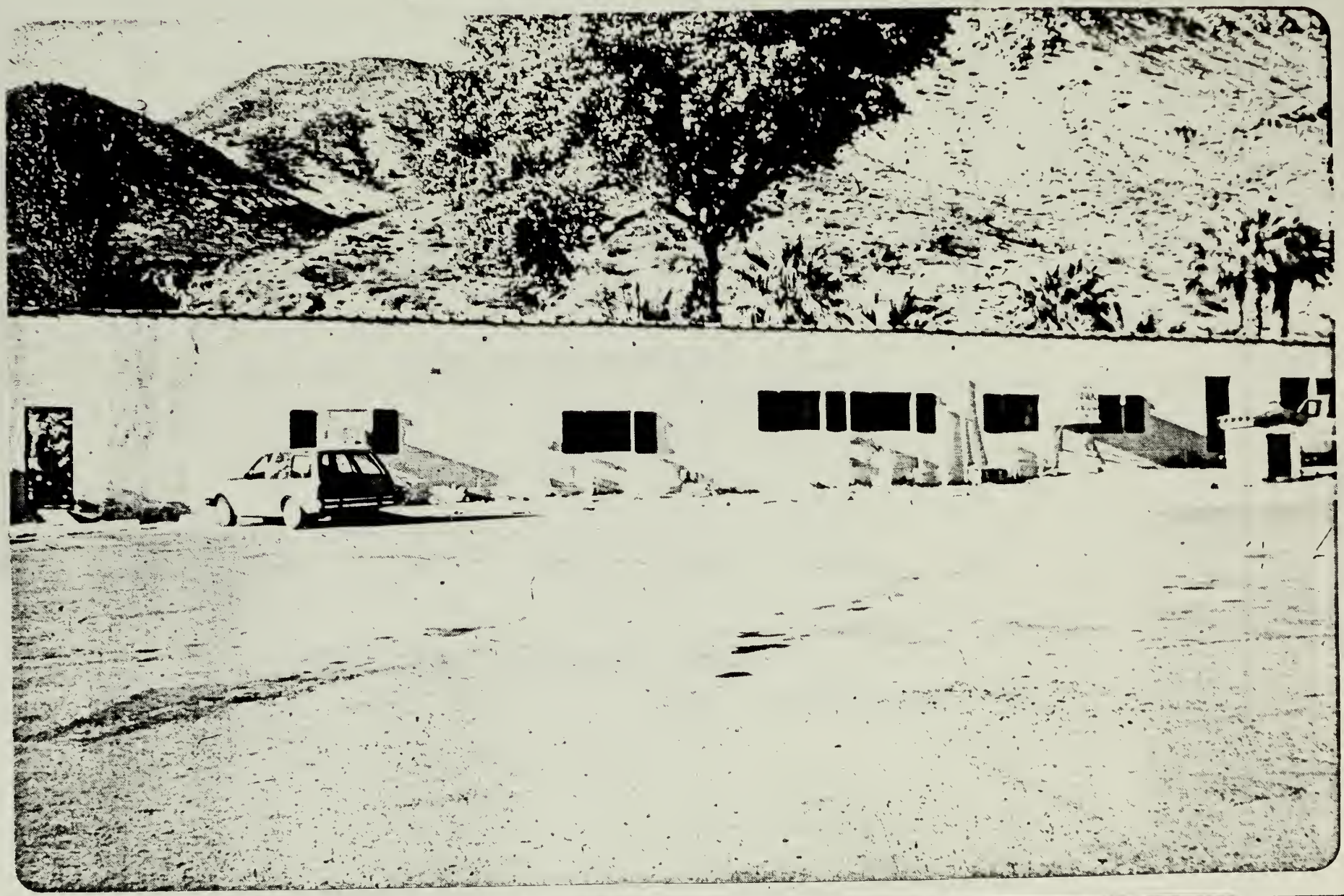
Q_{100} = 8500 CFS
S = 0.05
n = 0.045
A_{100} = 510 S.F.
V_{100} = 16.7 FPS

Q_{PM} = 36,400 CFS
S = 0.05
n = 0.045
A_{PM} = 1375 S.F.
V_{PM} = 26.5 FPS

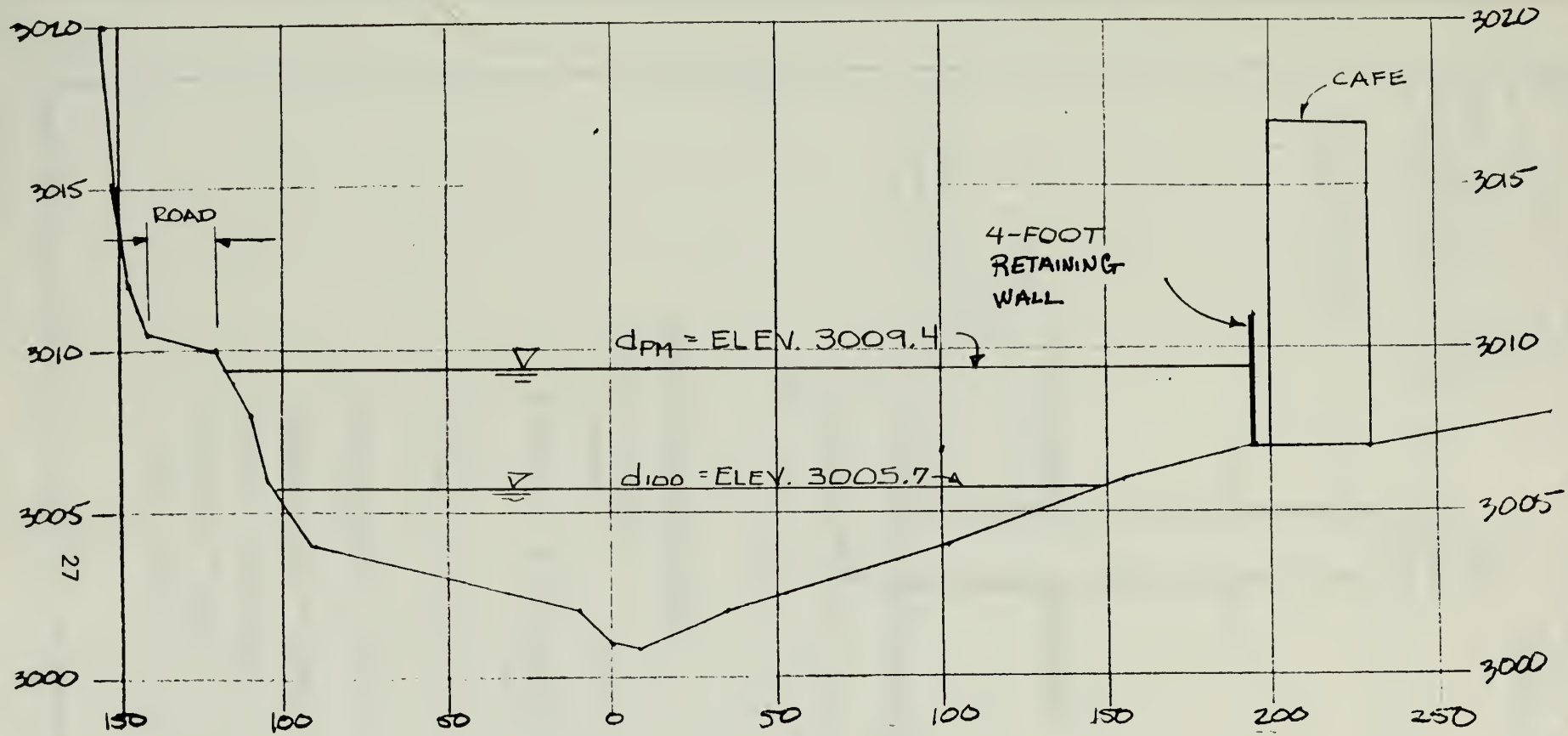
Park DEATH VALLEY
Area SCOTTY'S CASTLE
Project CASTLE AREA
Feature SECTION 2C
NATIONAL PARK SERVICE
DENVER SERVICE CENTER
By
Date
Checked
Date
Sheet 18
of
Pkg.
Account



Photograph No. 3
Gas Station at East End Parking Area
(Proposed Dike Ends Near Car at Center of Photo)



Photograph No. 4
Cafe Apartments Wall Location Looking North (Wall will be 4' high, approx. window sill height and run parallel to the building.)



27

SCOTTY'S CASTLE 2D

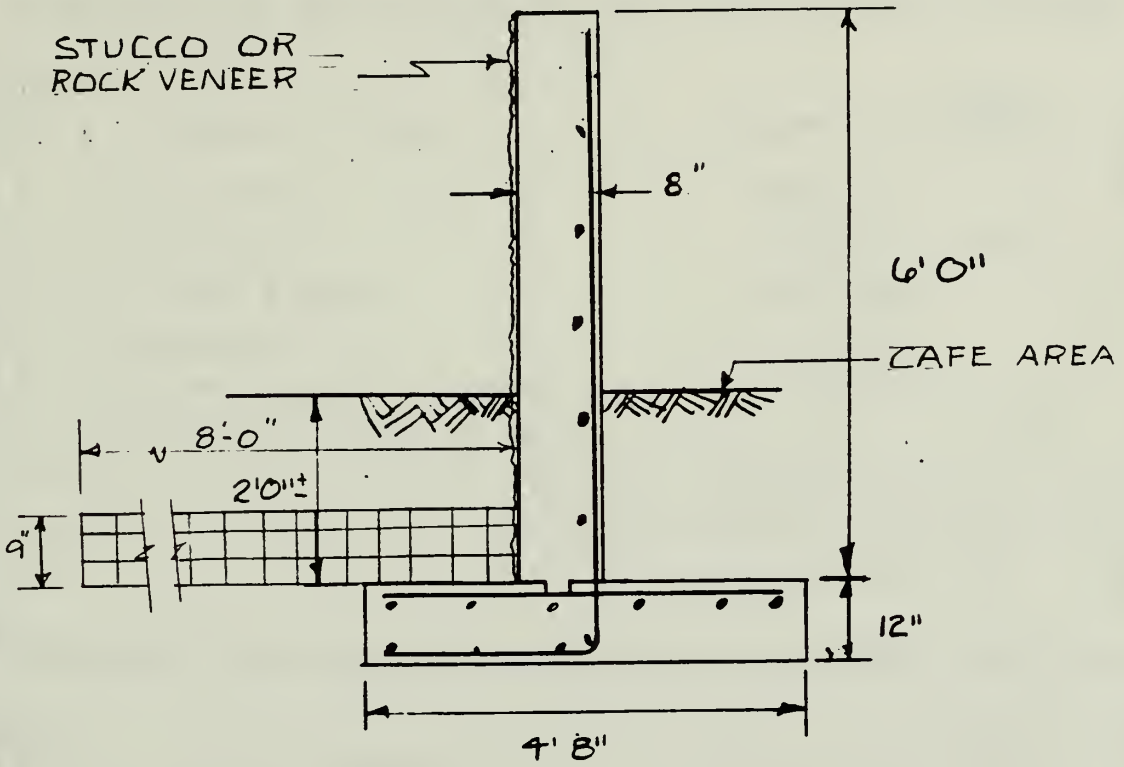
Q_{100} = 8,500 CFS
n = 0.045
S = 0.04

Q_{PM} = 36,400 CFS

Park DEATH VALLEY NM		NATIONAL PARK SERVICE DENVER SERVICE CENTER	Sheet 19
Area SCOTTY'S CASTLE			of
Project CASTLE AREA			Pkg.
Feature SECTION 2D	Date	By / Checked	Date / Account

FORM D 8 C - 44

Park DEATH VALLEY NM	NATIONAL PARK SERVICE DENVER SERVICE CENTER		Sheet 21
Area SCOTTY'S CASTLE			of
Project CASTLE AREA	By	Checked	Pkg.
Feature RETAINING WALL AT CAFE	Date	Date	Account



RETAINING WALL

CAFE AREA

LENGTH = 300 FT.

AREA = 8.67 $\frac{\text{CU.FT}}{\text{LIN. FT.}}$

VOLUME = 8.67 C.F. X 300 = 96.3 C.Y.

EXCAVATION = $[5' \times 3' + (8'-1.67) 2] 300$ = 300. C.Y.

GABION MATTRESS = $8 \cdot \frac{9}{12} \cdot 300$ = 67. C.Y.

REPAIR PAVEMENT = 9X300 = 300 S.Y.

STUCCO FINISH = 4X300 = 1200 S.F.

FILTER FABRIC = 67 C.Y ÷ ¼ Yd. = 275 S.Y.

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FORM D S C - 44

Park DEATH VALLEY N M	NATIONAL PARK SERVICE DENVER SERVICE CENTER		Sheet 22
Area SCOTTY'S CASTLE			of
Project CASTLE AREA	By	Checked	Pkg.
Feature ESTIMATED COSTS	Date	Date	Account

DETERMINE ESTIMATED COST OF DIVERSION DIKE

ITEM No.	DESCRIPTION	QUANTITY	UNIT PRICE	ESTIMATED COST
1.	IMPORTED FILL	3300 C.Y.	15⁻	$49,500⁻
2.	GABIONS	266 C.Y.	200⁻	53,200⁻
3.	FILTER FABRIC	1065 S.Y.	2⁻	2,130⁻
4.	CLEARING	LUMP SUM	—	2,500⁻
5.	IMPERVIOUS MEMBRANE	450 S.Y.	4⁻	1,800⁻
6.	MISC. CONTINGENCIES	—	15%	16,370⁻
	TOTAL DIKE COST (NET) =			$125,500⁻

GROSS = NET x 1.31 = $ 164,500⁻

*DETERMINE ESTIMATED COST OF CAFE RETAINING WALL

ITEM NO.	DESCRIPTION	QUANTITY	UNIT PRICE	ESTIMATED COSTS
1.	RETAINING WALL CONCRETE	100 C.Y.	450⁻	45,000⁻
2.	EXCAVATION	300 C.Y.	10⁻	3,000⁻
3.	GABIONS	67 C.Y.	150⁻	10,000⁻
4.	FILTER FABRIC	300 S.Y.	2⁻	600⁻
5.	STUCCO FINISH	1200 S.F.	4·	4,800⁻
6.	REPAIR PAVEMENT	300 S.Y.	20⁻	6.000⁻
	TOTAL CAFE RETAINING WALL COSTS (NET) =			$69,400⁻

GROSS = NET x 1.31 = $ 91,000⁻

* SEE ALT. A, SCOTTY'S CASTLE SUPPLEMENT SHTS. 10 & 11.

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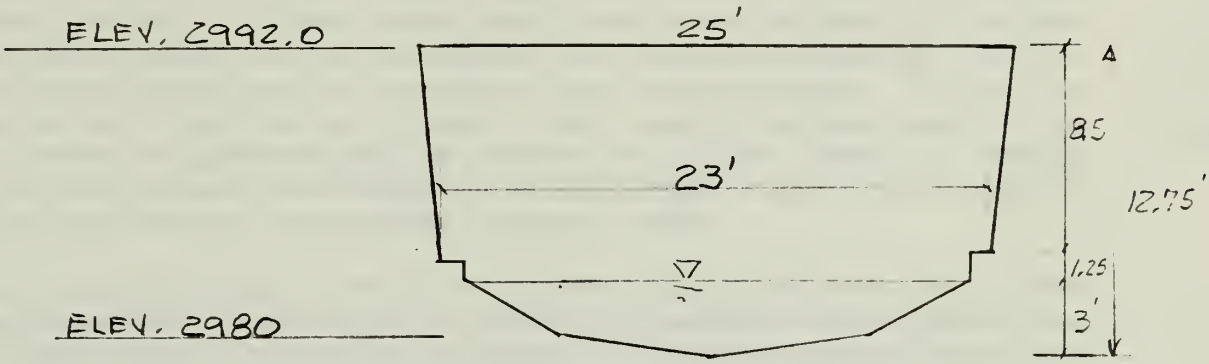
FORM D S C - 44

Park DEATH VALLEY NM	NATIONAL PARK SERVICE DENVER SERVICE CENTER			Sheet 13A
Area SCOTTY'S CASTLE				of
Project CASTLE AREA	By		Checked	Pkg.
Feature SCOTTY'S BRIDGE	Date		Date	Account

DETERMINE MAXIMUM FLOW THRU SCOTTY'S BRIDGE:

GIVEN DIMENSIONS:



AREA = 275 ft³

n = .02 ; P = 43.71 Ft.

S = .05

MAXIMUM VELOCITY:

$$V = \frac{1.486}{n}\left(\frac{A}{P}\right)^{2/3} S^{1/2} = 56.62 \text{ Ft./Sec.}$$

QUANTITY: Q = 15,570 cfs FOR CHANNEL

ASSUME BOX CULVERT:

USE AS UNRESTRICTED OUTLET (ORIFACE)

$Q = CA\sqrt{2gh} = .6(275)\sqrt{64.4(13)} = 4775 \text{ ft}^3/\text{Sec.}$

USE AS RESTRICTED BOX CULVERT, DIMEN. AS SHOWN

$Q = \text{Max. at } y = 3.8' = (1)(275-93)\sqrt{64.4(3.8)} = 2842 \text{ cfs}$

IF CONCRETE CHANNEL IS CONSTRUCTED:

b = 18' ; h could be 9' ; S could be .05;

$$Q = A\frac{1.486}{.015}\cdot\left(\frac{A}{P}\right)^{2/3} S^{1/2} = 9,780 \text{ cfs}$$

USE 2842 CFS AS MAXIMUM CAPACITY OF BRIDGE

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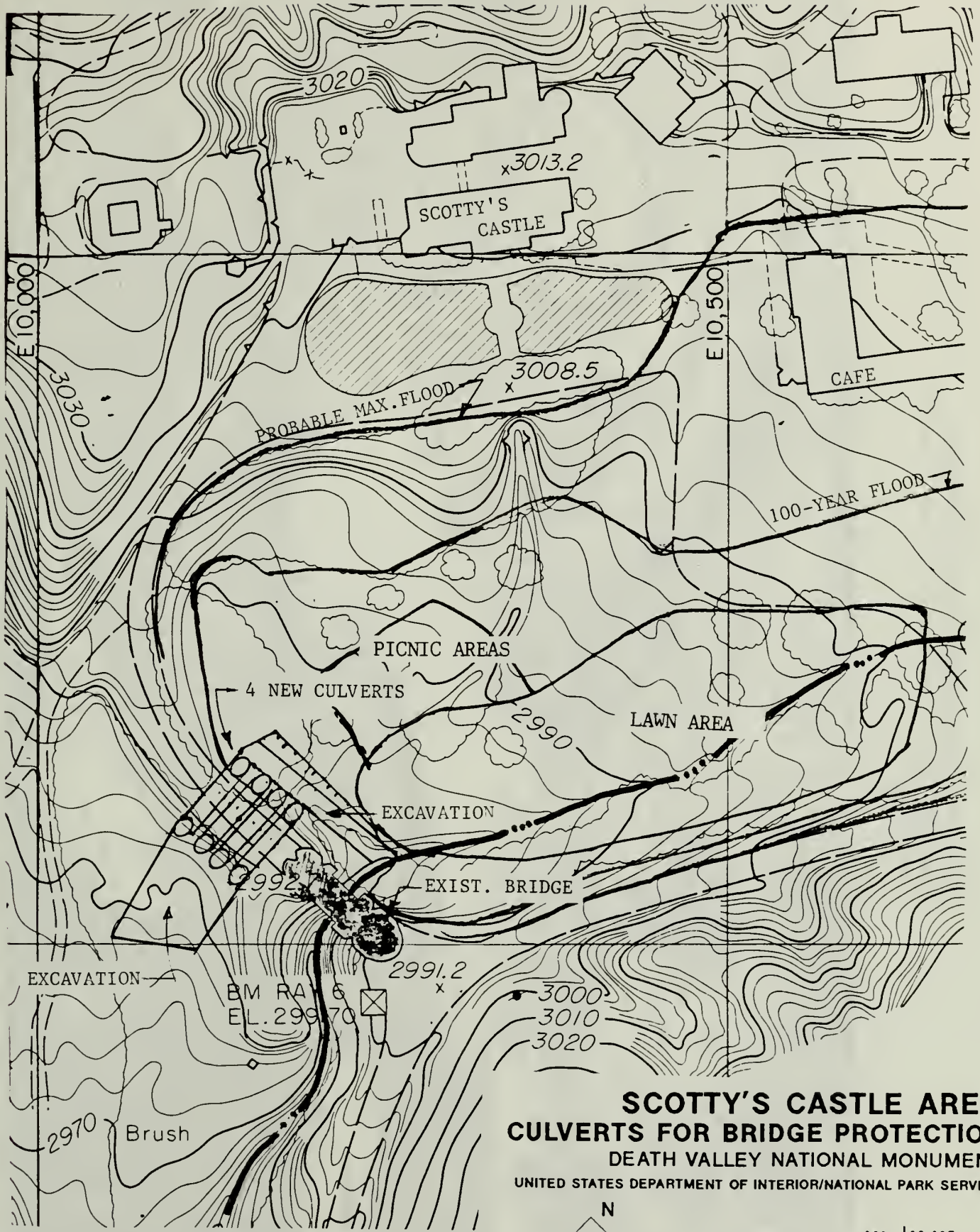
Without the concrete channel, the bridge opening will allow only about 2850 cubic feet per second (CFS) to pass. This leaves 5,650 CFS to be carried by culverts. The graphic entitled Culverts for Bridge Protection and Photograph No. 5 shows the proposed location of four 15.3 feet wide by 9.2 feet high by 80 feet long steel plate pipe-arches. Costs for these culverts would be $243,500 for the complete project.

The use of box culverts made of concrete rather than circular metal culverts may be more pleasing and conform more to the general architectural style, however the cost would approximately double. Another possible option is to design and construct a "wash out" to replace the roads. This concept involves removal of the present road and rebuilding the road of materials which would intentionally and easily erode during a flood, e.g., coarse sand and gravel without silts or clay. A lowering of a portion of the road below the elevation of the bridge similar to a low water crossing will allow water to overtop the road at this point, causing failure (wash out) of the entire road thus fully enlarging the channel capacity. In using this concept the north portion of the bridge, behind the rock structure, should be reinforced with concrete to prevent erosional damage. This wash out concept offers two advantages over that of culverts. First, impacts to the visual integrity of the site would be minimal, the appearance being very similar to that of today. Second, the complete wash out of the road will permit the passage of any cars or trailers which might otherwise be caught in a flood and washed to the site, causing a pile up of water.

The following nonstructural measures would also be implemented in this alternative. Rainfall monitoring gauges could be placed throughout the Grapevine drainage above Scotty's Castle. They would report rainfall by radio to a computer (several brands of personal computers are adequate for this use), and the computer would be programmed to determine the flood level a given amount of rainfall would be expected to produce. If the calculated flood level were above a predetermined level, the computer could automatically alert the dispatcher or set off an alarm system. The alarm could be sirens and/or flashing lights located around the flood hazard area by the castle.

The rainfall gauges would have to be located in a grid pattern throughout the Grapevine drainage above the castle. The number and spacing of the gauges would have to be calculated based on the desired level of probability of monitoring the smallest diameter storm cell to produce a 100-year flood or larger by at least one gauge. This arrangement would require approximately 8 gauges to insure monitoring of the smallest 30 minute duration 100-year precipitation storm that would produce a 100-year or larger flood, or 25 gauges to insure monitoring the smallest 30 minute duration probable maximum precipitation storm that would produce a 100-year or larger flood. To insure radio communications between gauges and the computer during electrical storms the repeater would have to be a redundant system. Depending on where in the drainage the rainfall concentrated, the rainfall gauge system could provide 10 to 45 minutes warning time. Since Tie Canyon flood flows would not directly affect any of the visitor use areas at the castle, mitigation measures would not be implemented for it. The total cost of construction for the rainfall gauge system in 1988 would be approximately $90,000 to $205,500, depending on which density of gauges was used.

Water Intake Area. The existing dike would be breached by the 100-year flood and will severely damage the water collection system. As shown on the graphic entitled Water Intake, Structural Mitigation and sections 2A.0-2A.5 the dike could be expanded to contain the 100-year flood. The slope of the dike adjacent to the flow would be lined with gabions. The gabions would be keyed into the toe of the dike embankment 2 feet vertically and 4 feet horizontally to prevent scouring action at the toe. Filter fabric would prevent sand from being washed through the gabions and being swept away. An impervious membrane would be located at the center of the dike to facilitate installation and would be keyed into the original ground a minimum of 2 feet which would prevent failure of the dike by seepage through the dike. The total cost of the dike to protect the water collection system would be $59,000. This protection plan will be implemented in all the alternatives.

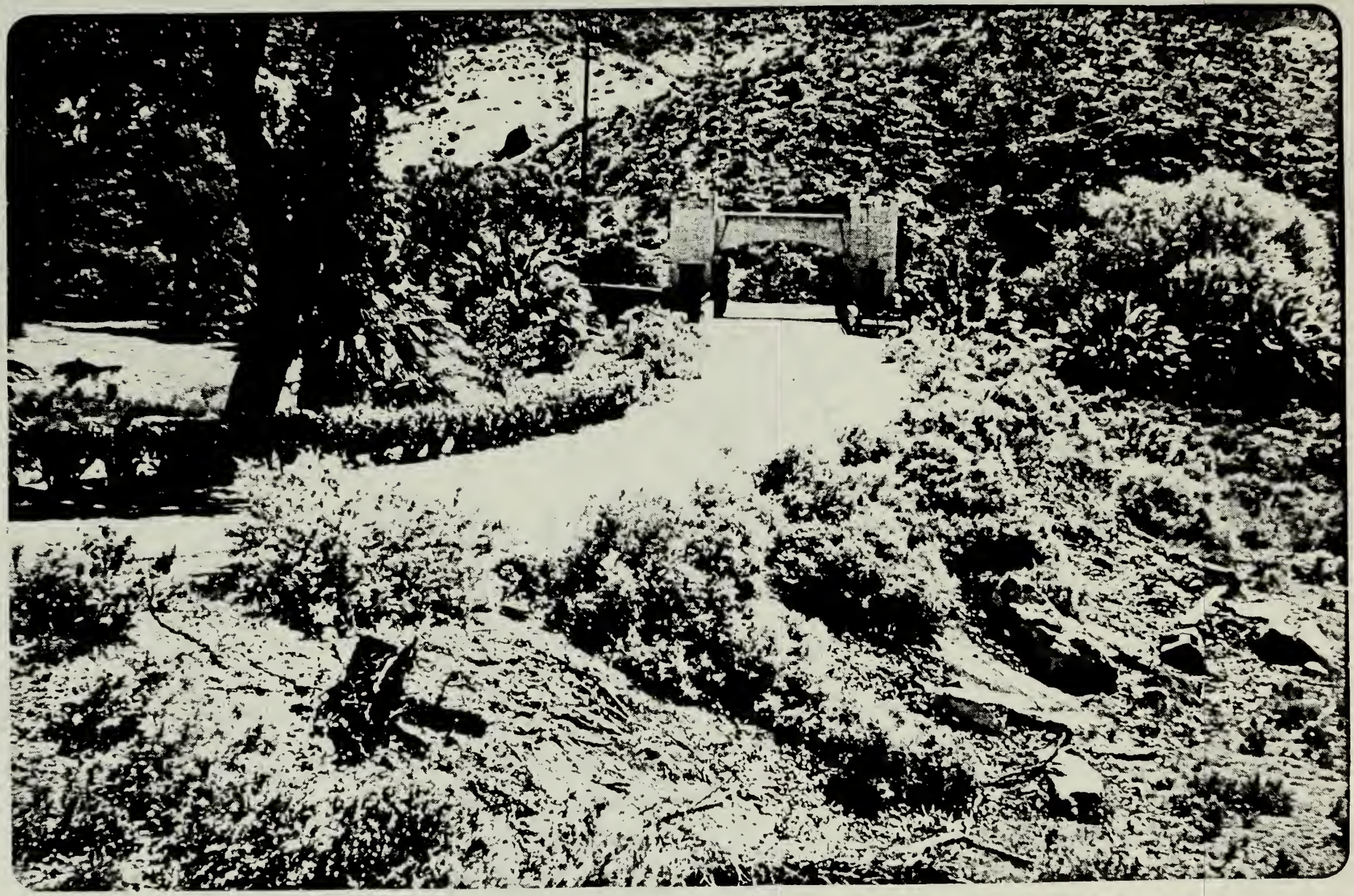


SCOTTY'S CASTLE AREA
CULVERTS FOR BRIDGE PROTECTION
DEATH VALLEY NATIONAL MONUMENT
UNITED STATES DEPARTMENT OF INTERIOR/NATIONAL PARK SERVICE

N

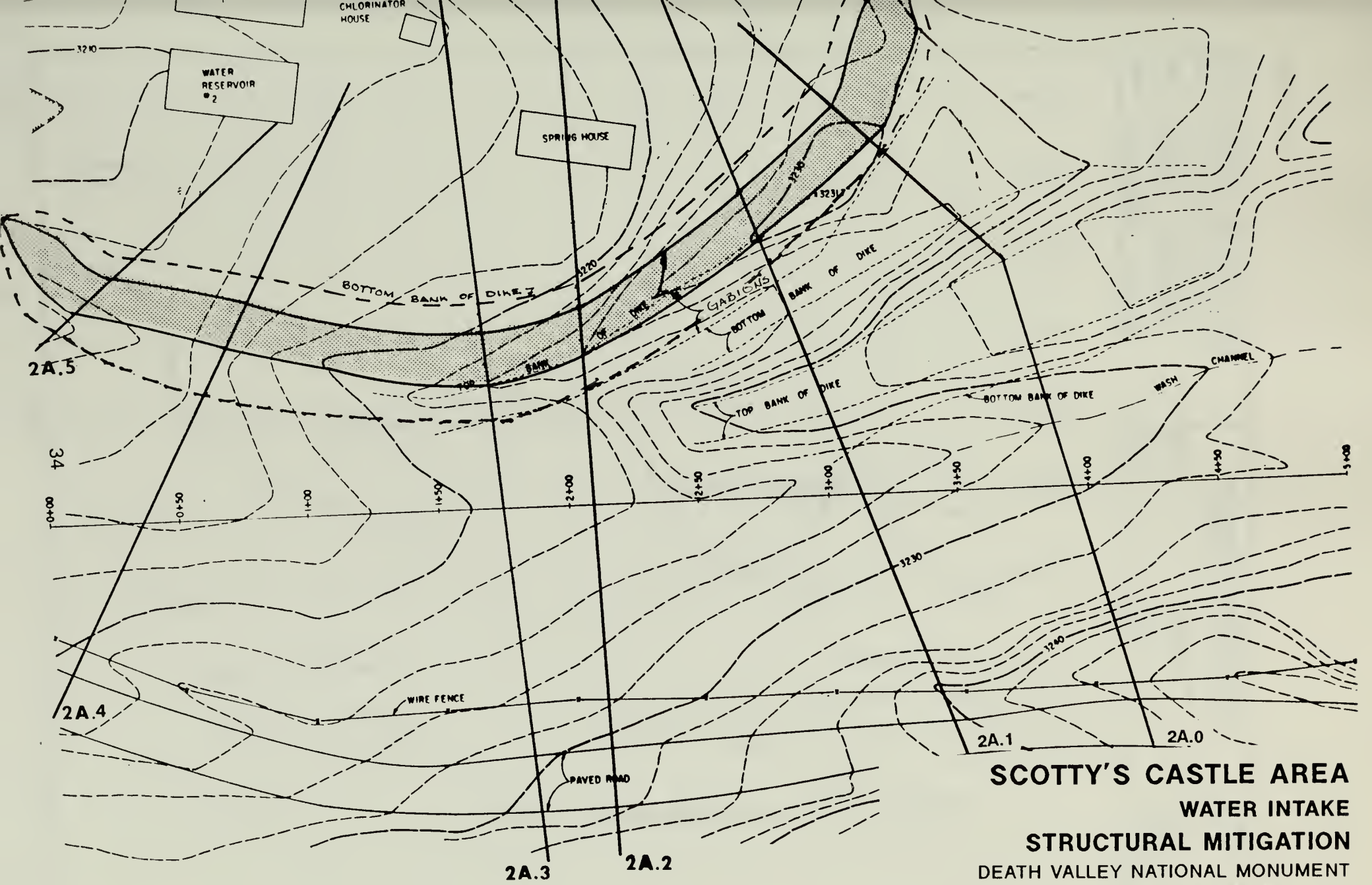
SCALE 1":100'

143	40,105
DSC	AUG 89



Photograph No. 5
Scotty's Castle Entrance Bridge. Looking Southeast (Proposed culverts would be placed under the road in foreground)

Flow →



SCOTTY'S CASTLE AREA

WATER INTAKE

STRUCTURAL MITIGATION

DEATH VALLEY NATIONAL MONUMENT

UNITED STATES DEPARTMENT OF INTERIOR/NATIONAL PARK SERVICE

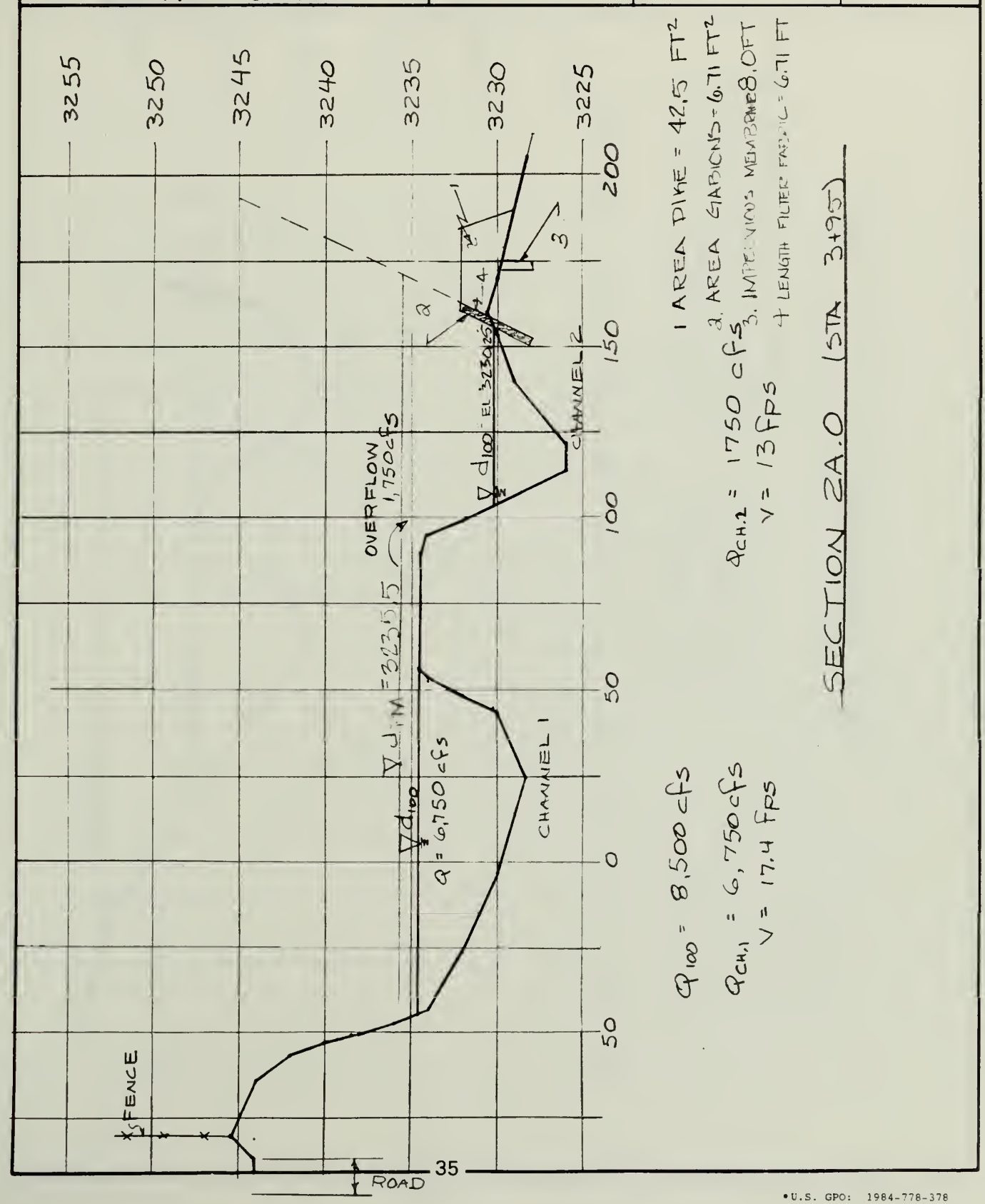
N

SCALE 1":50'

143	40,107
DSC	AUG 89

FORM D S C - 44

Park DEATH VALLEY NM	NATIONAL PARK SERVICE DENVER SERVICE CENTER		Sheet 15
Area SCOTTY'S CASTLE			of
Project WATER INTAKE	By	Checked	Pkg.
Feature SECTION 2A.0	Date	Date	Account



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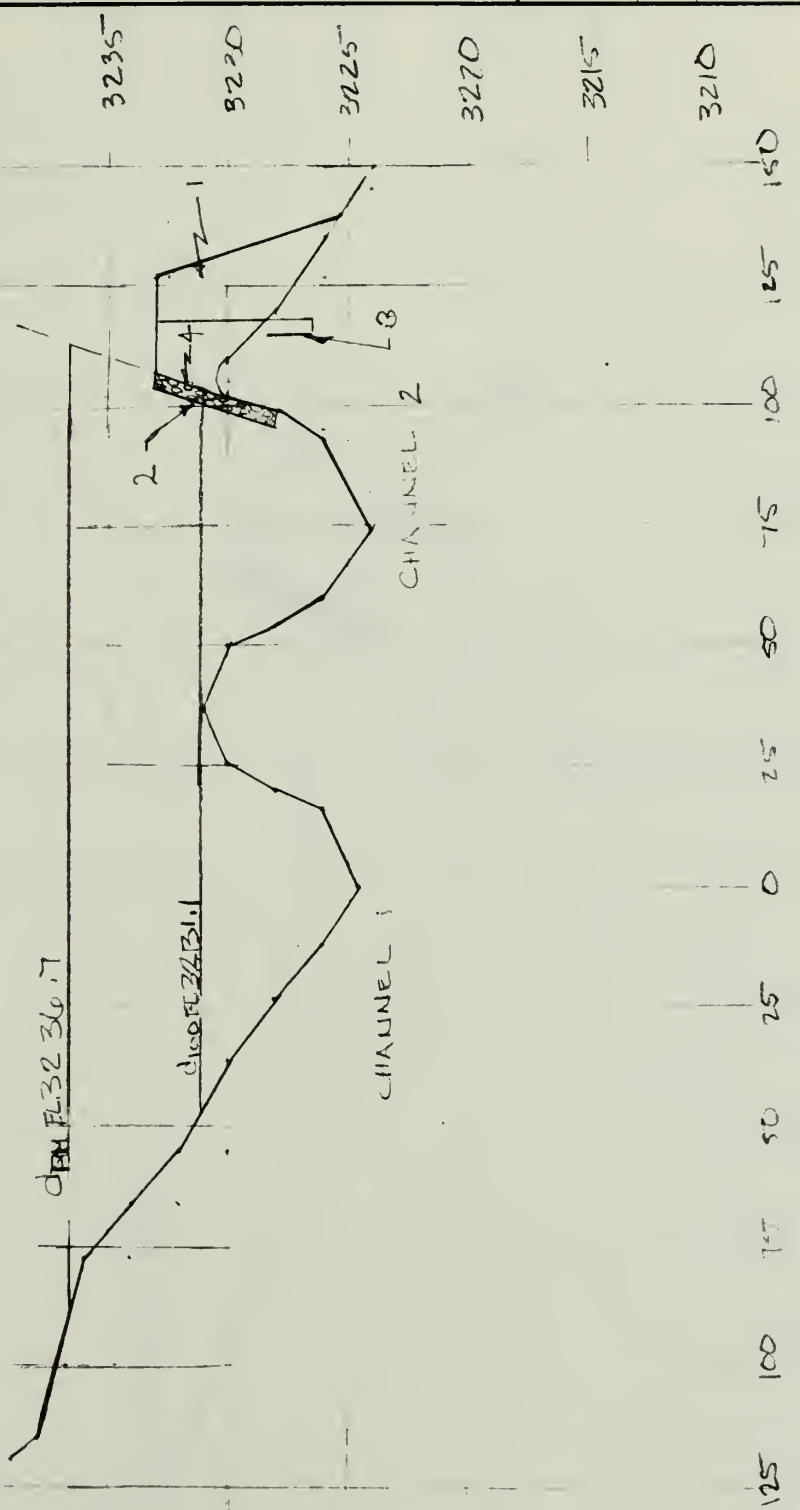
FORM D S C - 44

Park DEATH VALLEY NM	NATIONAL PARK SERVICE DENVER SERVICE CENTER		Sheet 16
Area SCOTTY'S CASTLE			of
Project WATER INTAKE	By TG	Checked	Pkg.
Feature SECTION 2A.1	Date 3/12/85	Date	Account



$Q_{100} = 8,370$ CFS
$V_{100} = 15.42$ FPS

$Q_{PM} = 36,400$ GPM
$V_{PM} = 24.10$ FPS

1. AREA DIKE = 135.0 FT²
2. AREA GABIONS = 8.94 FT²
3. IMPERVIOUS MEMBRANE 11.0 FT
4. LENGTH FILTER FABRIC = 8.74 FT

SECTION 2A.1 (STATION 3+12)

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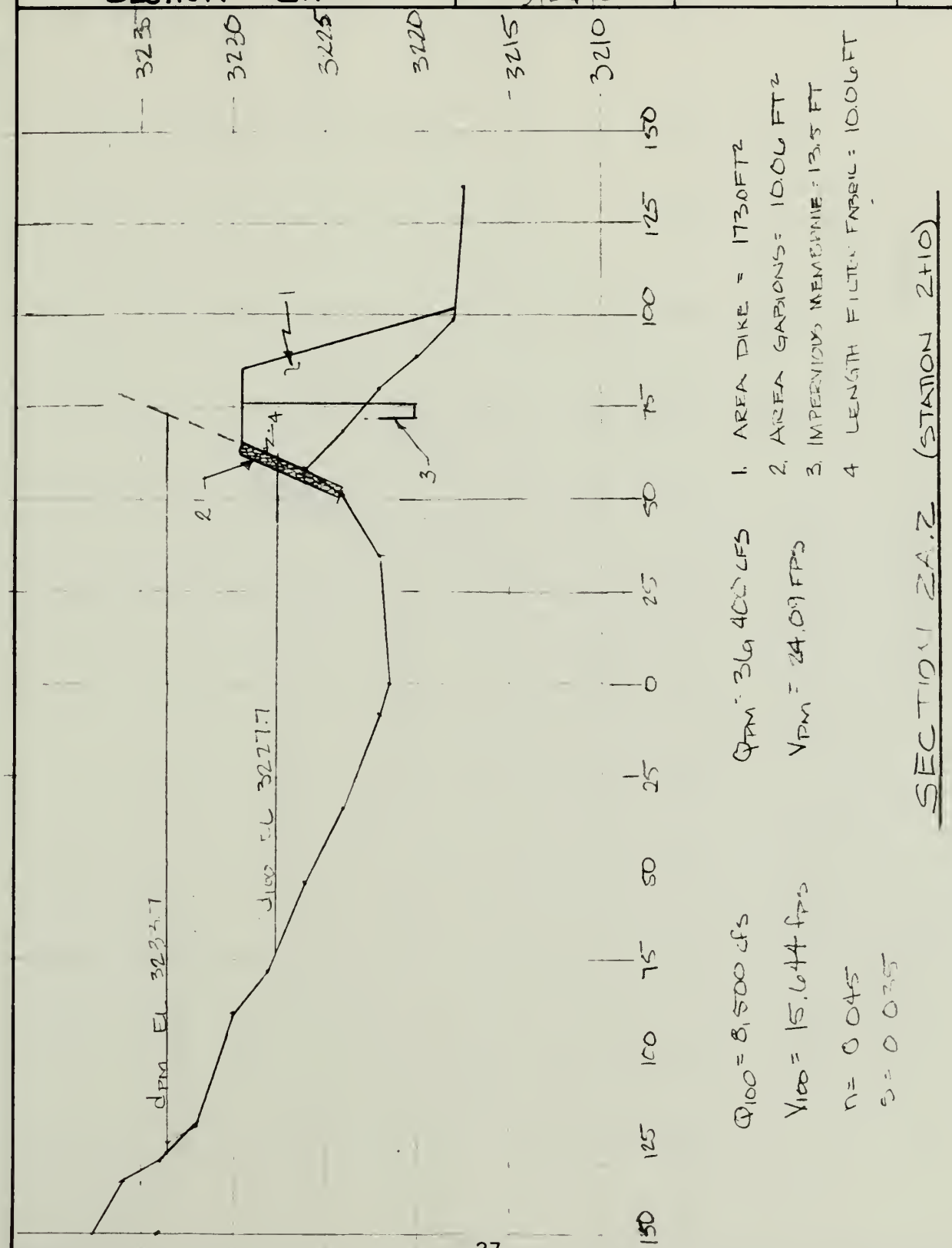
FORM D S C - 44

Park DEATH VALLEY NM	NATIONAL PARK SERVICE DENVER SERVICE CENTER		Sheet 17
Area SCOTTY'S CASTLE			of
Project WATER INTAKE	By TG	Checked	Pkg.
Feature SECTION 2A.2	Date 5/24/85	Date	Account



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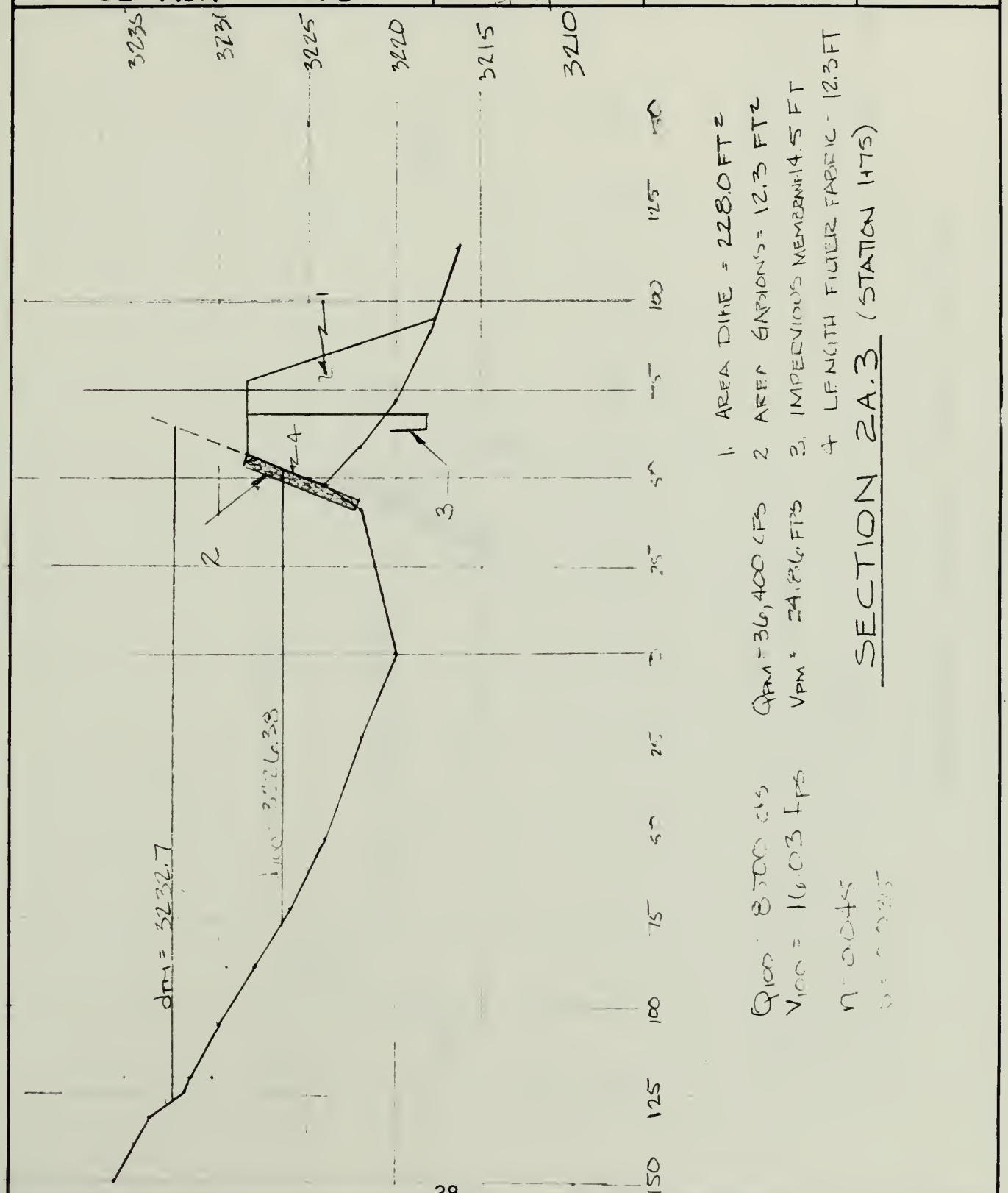
FORM D S C - 44

Park DEATH VALLEY NM	NATIONAL PARK SERVICE DENVER SERVICE CENTER		Sheet 18
Area SCOTTY'S CASTLE			of
Project WATER INTAKE	By	Checked	Pkg.
Feature SECTION 2A.3	Date 3/21/85	Date	Account



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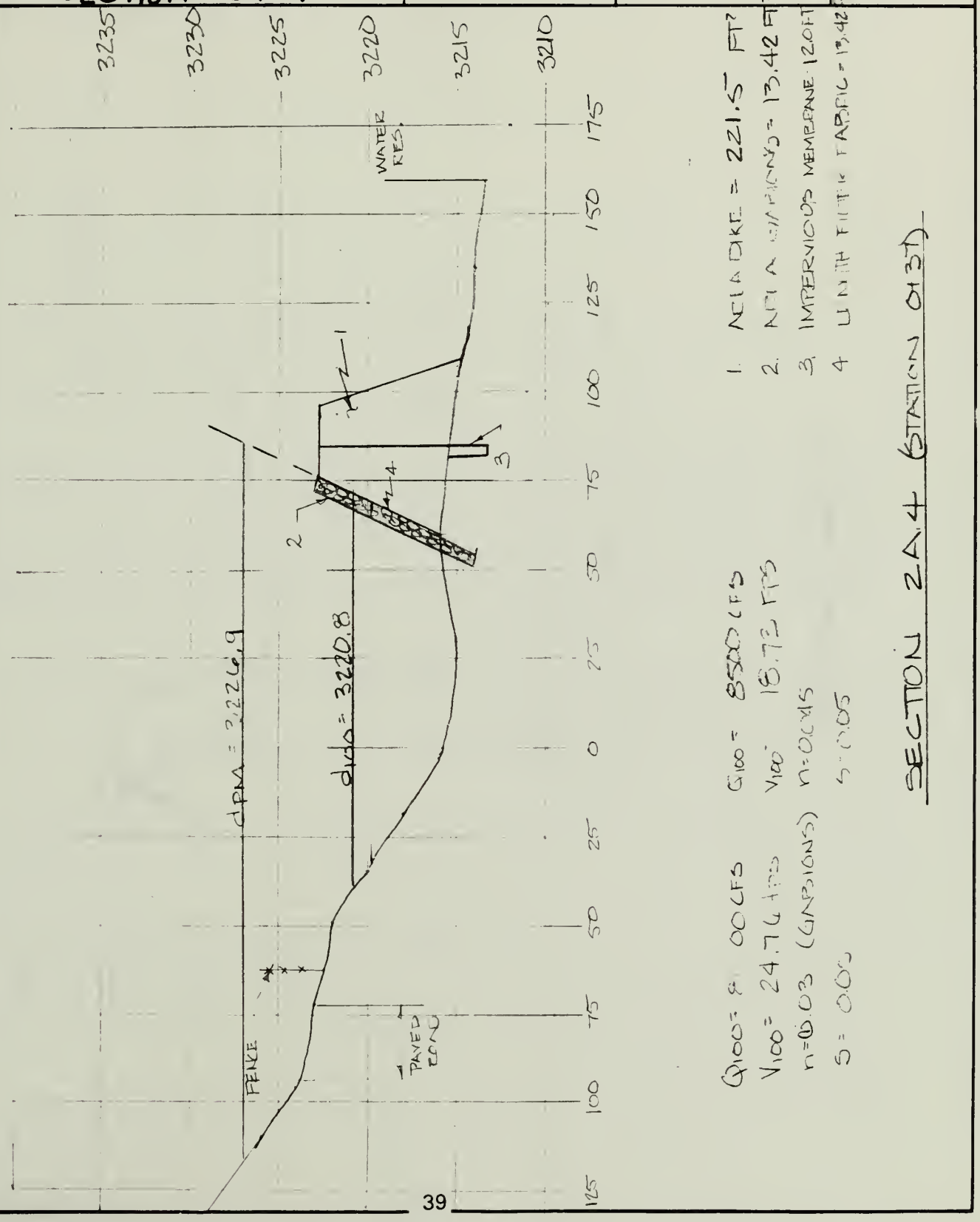
FORM D S C - 44

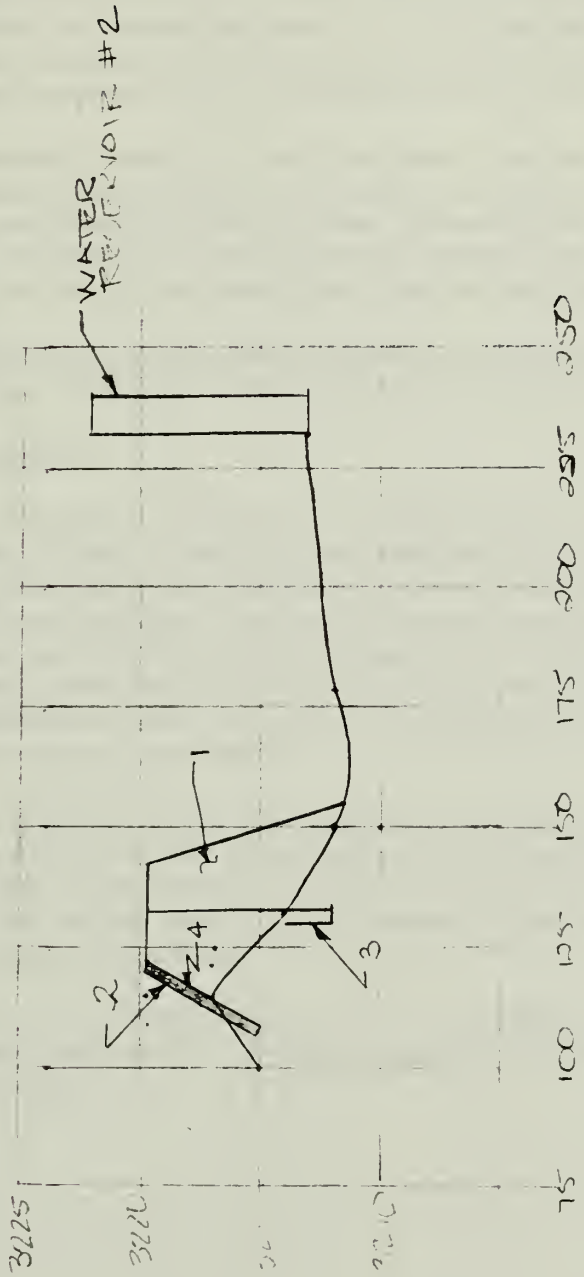
Park DEATH VALLEY NM	NATIONAL PARK SERVICE DENVER SERVICE CENTER		Sheet 19
Area SCOTTY'S CASTLE			of
Project WATER INTAKE	By	Checked	Pkg.
Feature SECTION 2A.4	Date	Date	Account



*U.S. GPO: 1984-778-378

FORM D S C - 44

Park DEATH VALLEY NM	NATIONAL PARK SERVICE DENVER SERVICE CENTER		Sheet 20
Area SCOTTY'S CASTLE			of
Project WATER INTAKE	By	Checked	Pkg.
Feature SECTION 2A.5	Date	Date	Account



1. AREA DIKE = 164.5 FT²
2. AREA GABIONS = 8.7 FT²
3. IMPERVIOUS MEMBRANE = 12.0 FT
4. FILTER FABRIC = 8.7 FT

SECTION 2A.5

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Alternative B

This alternative consists of an underground box culvert to carry the 100-year flood. Flared inlet and outlet structures will be needed. Approximately 320 feet of earth channel has to be excavated at the outlet to provide a 2-1/2% grade for the outlet flow from the culvert. This channel is lined with riprap for 100 feet to prevent streambed erosion and the undermining of the culvert. A 14-foot bridge or other structural strengthening of the box culvert is required for the access road to the cafe parking area. At the culvert inlet a diversion channel has been added which will divert normal stream flow up to 500 cubic feet per second into the restored streambed. For the probable-maximum flood, a retaining wall can be placed around the cafe. As in alternative A, the retaining wall around the cafe for the PM flood protection is determined to be necessary only if there are sleeping quarters in the cafe during flood season. This alternative assumes that the public will be protected from the probable maximum flood by some nonstructural means.

By detailed inventory of the rocks, gravel, and plants in the streambed, the streambed can be effectively restored after the box culvert construction. With the culvert underground, only the inlet and outlet structures will be visible. Normal stream flow up to 500 cubic feet per second, which is the capacity of the existing natural channel, will be diverted from entering the box culvert, and will flow through the castle area in the restored natural streambed.

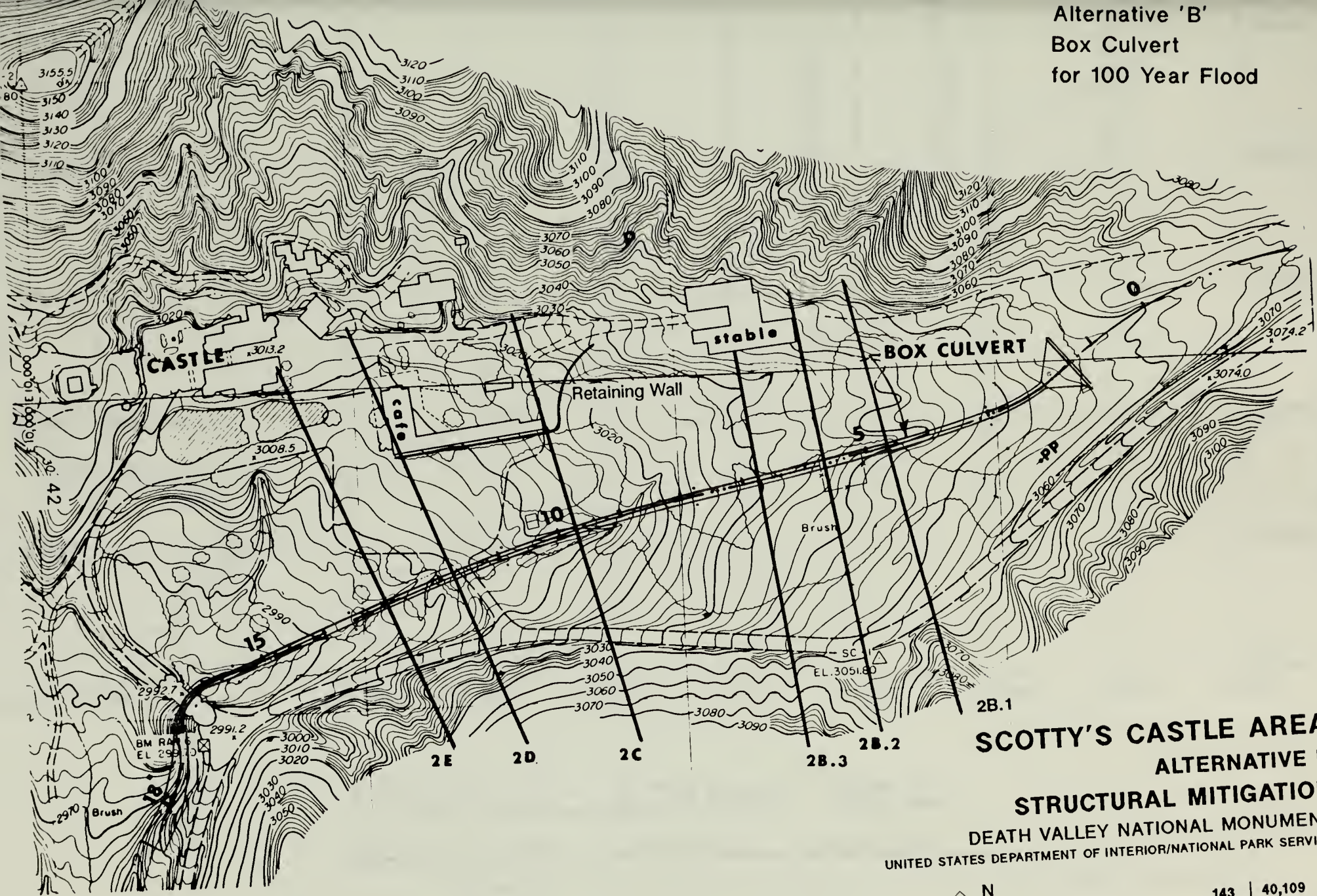
A plan and a profile of the box culvert are shown on the following four pages. Quantities and costs are given on page 46. The costs of all the alternatives are tabulated at the end of this section.

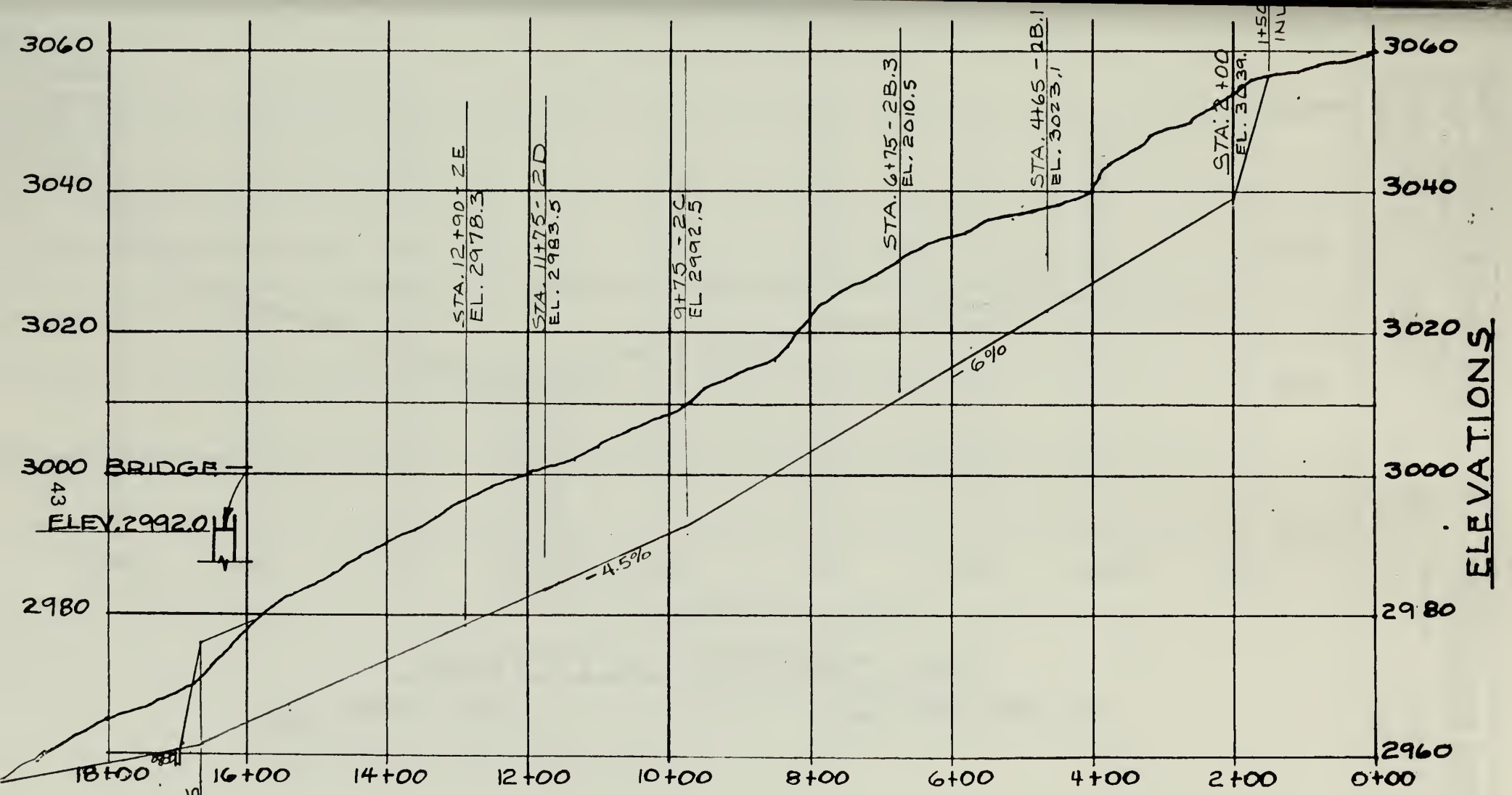
Alternative C

This alternative consists of an underground box culvert to carry the flow from the probable maximum flood. Flared inlet and outlet structures are needed. Approximately 400 feet of earth channel, 47 feet wide. has to be excavated at the outlet to provide a 2-1/2% grade for the outlet flow from the culvert. The first 100 feet of the earth channel will be lined with riprap to prevent erosion and the undermining of the culvert. A 34-foot bridge or other structural strengthening of the box culvert will be required for the cafe parking access road. At the inlet, a diversion channel is designed to allow up to 500 cubic feet per second of flow to continue down the natural (reconstructed) streambed.

By detailed inventory of the existing rocks and plants in the existing streambed, the streambed can be reconstructed after the box culvert construction to nearly original conditions. The culvert will be visible only at the inlet and outlet structures. Normal stream flow will continue up to 500 cubic feet per second, which is the capacity of the existing streambed; and, flow will be in the reconstructed streambed.

A plan of the culvert is on page 47, and a profile is on page 48. Estimated quantities and costs are given on page 49. Comparative costs of the various alternatives are tabulated at the end of this section.


Alternative 'B'
Box Culvert
for 100 Year Flood
CASTLE
cafe
stable
BOX CULVERT
Retaining Wall
Brush
Brush
SC
EL. 3051.80
BM RA
EL. 2993.0
2E
2D
2C
2B.3
2B.2
2B.1
SCOTTY'S CASTLE AREA
ALTERNATIVE B
STRUCTURAL MITIGATION
DEATH VALLEY NATIONAL MONUMENT
UNITED STATES DEPARTMENT OF INTERIOR/NATIONAL PARK SERVICE
N
SCALE 1":200'
143 | 40,109
DSC | AUG 89

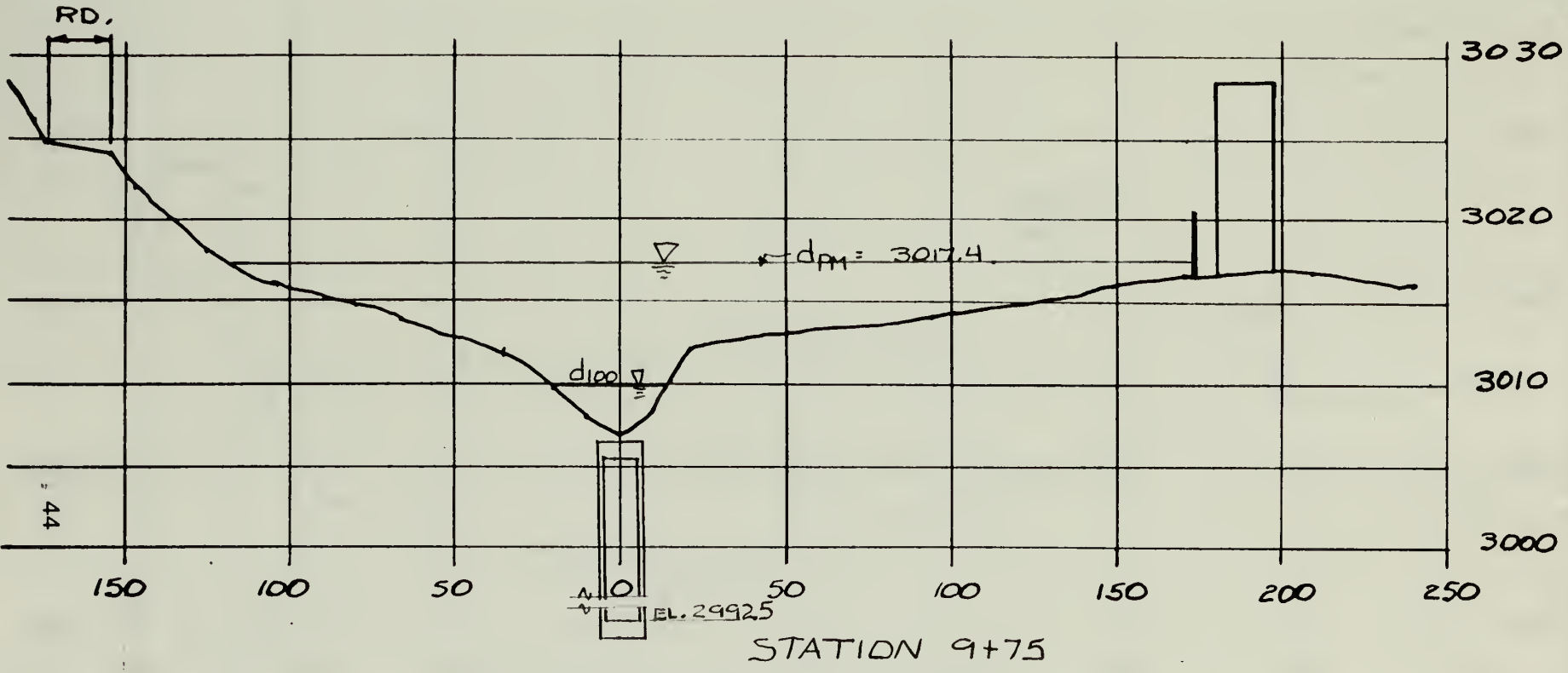


PROFILE - STREAM BED

SCOTTY'S - CASTLE AREA

SCALE: AS INDICATED

ALTERNATIVE 'B'
Q100 BOX CULVERT



SCOTTY'S CASTLE - 2C

Q_{100} = 8000 CFS

AREA CONC. = 59 S.F

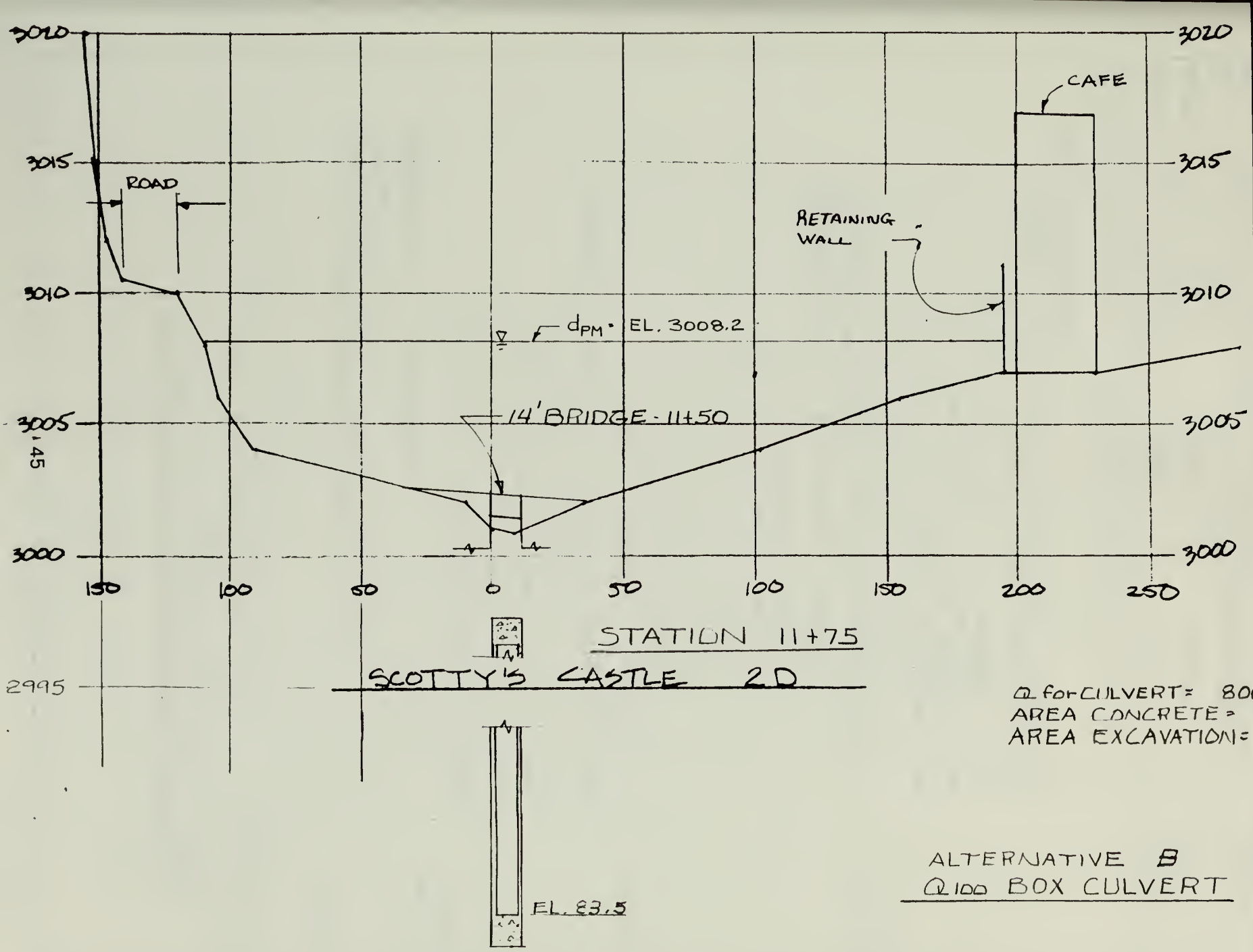
AREA EXCAVATION = 360 S.F.

Q_{PM} = 36,400 CFS

ALTERNATIVE 'B'

Q100 BOX CULVERT

Park: DEATH VALLEY NM			Sheet: of
Area: SCOTTY'S CASTLE	NATIONAL PARK SERVICE DENVER SERVICE CENTER		
Project: CASTLE AREA	By	Checked	Pkg.
Feature: SECTION 2C	Date	Date	Account



DEATH VALLEY
SCOTTY'S CASTLE
CASTLE AREA
SECTION 2D

Date	By
Date	Checked

NATIONAL PARK SERVICE
DENVER SERVICE CENTER

Q for CULVERT = 8000 CFS
AREA CONCRETE = 59SF
AREA EXCAVATION = 415S.F.

ALTERNATIVE B
Q100 BOX CULVERT

Sheet	of	Pkg.	Account

FORM D S C - 44

Park	DEATH VALLEY NM	NATIONAL PARK SERVICE DENVER SERVICE CENTER		Sheet 38
Area	SCOTTY'S CASTLE			of
Project	CASTLE AREA	By	Checked	Pkg.
Feature	Q100 BOX CULVERT	Date	Date	Account

ALTERNATIVE B: QUANTITIES & COSTS:

BOX CULVERT

INLET: Diversion for Stream flow of 500 CFS
21'x110'x1' = 85 4d³ @ 300 = $26,000.
Wall (cutoff) = 100'x1'x3' = 11 @ 450 = 5,000
Slab = (100+12)½(50)(1) = 104 Yd³ @ 450 = 47,000
Side Walls = (3+15)½(66) = 22 Yd³ @ 500 = 11,000
Grate: 1000 S.F @ 10 = 10,000 ——— # 99,000

CONCRETE CULVERT: (STA. 2+00 to 16+65) 59 @ 500 = 1,600,600

EXCAVATION: STA. 2+00 TO 4+65 = 360(265)
STA. 4+65 to 6+75 = 210(393)
STA. 6+75 to 9+75 = 300(393)
STA. 9+75 to 11+75 = 200(388)
STA. 11+75 to 12+90 = 115(418)
STA. 12+90 to 16+65 = 375(370)
20,750 C.Y @ $ 20 = 415,000

OUTLET Cutoff wall: 27 x 3x1 = 34d³ @ 500 = $1,500.
Wing Walls: 2(341) @ 500 = 12,600
Slab = (12+28)½(30) @ 300 = 6,700
Riprap = 27x 100 x 3 @ 50 = 15,000
Excavation = 320'(8)½ (27) @ 20 = 25,600
61,400

BRIDGE 14x26 @ 115 = 42,000

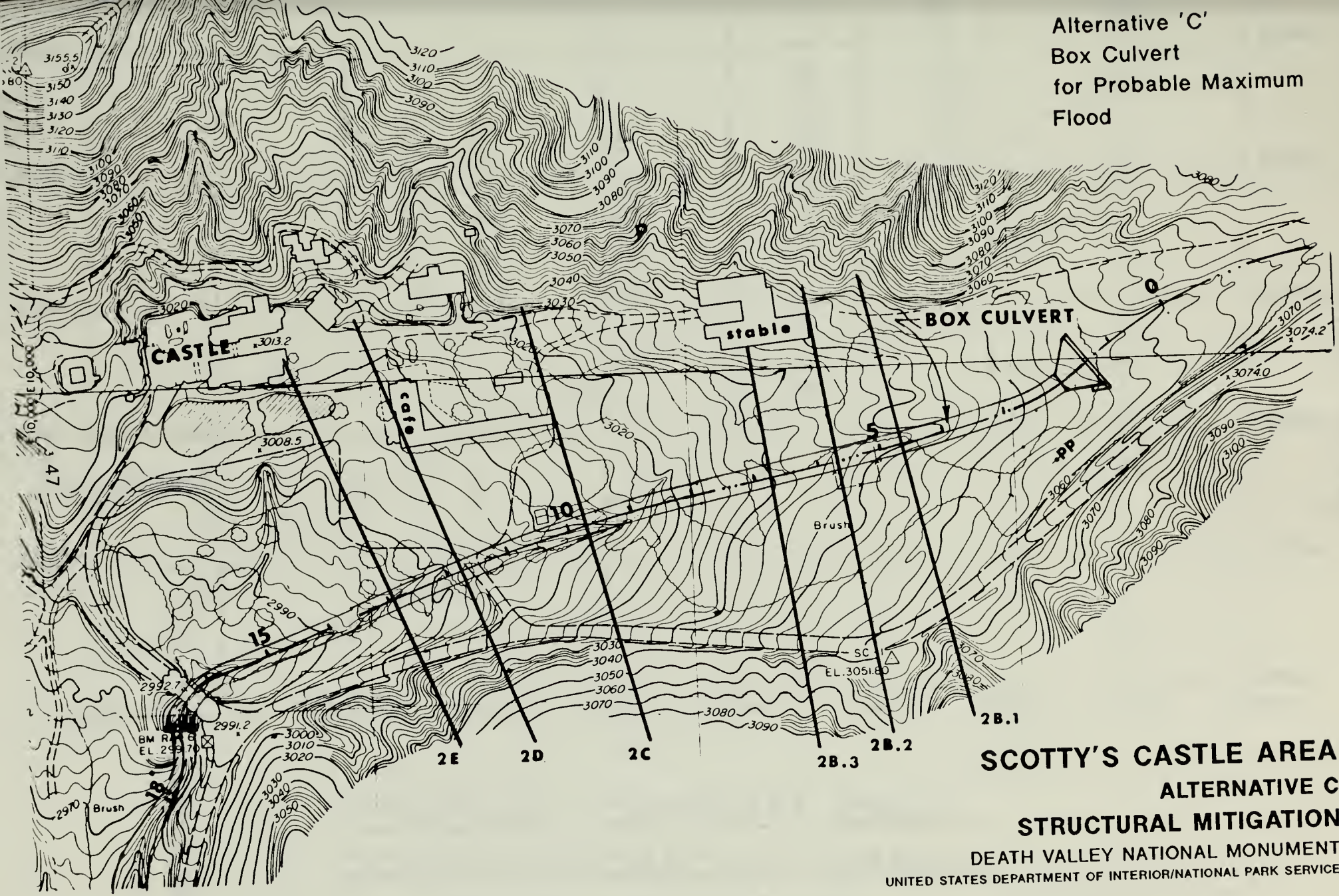
PMF

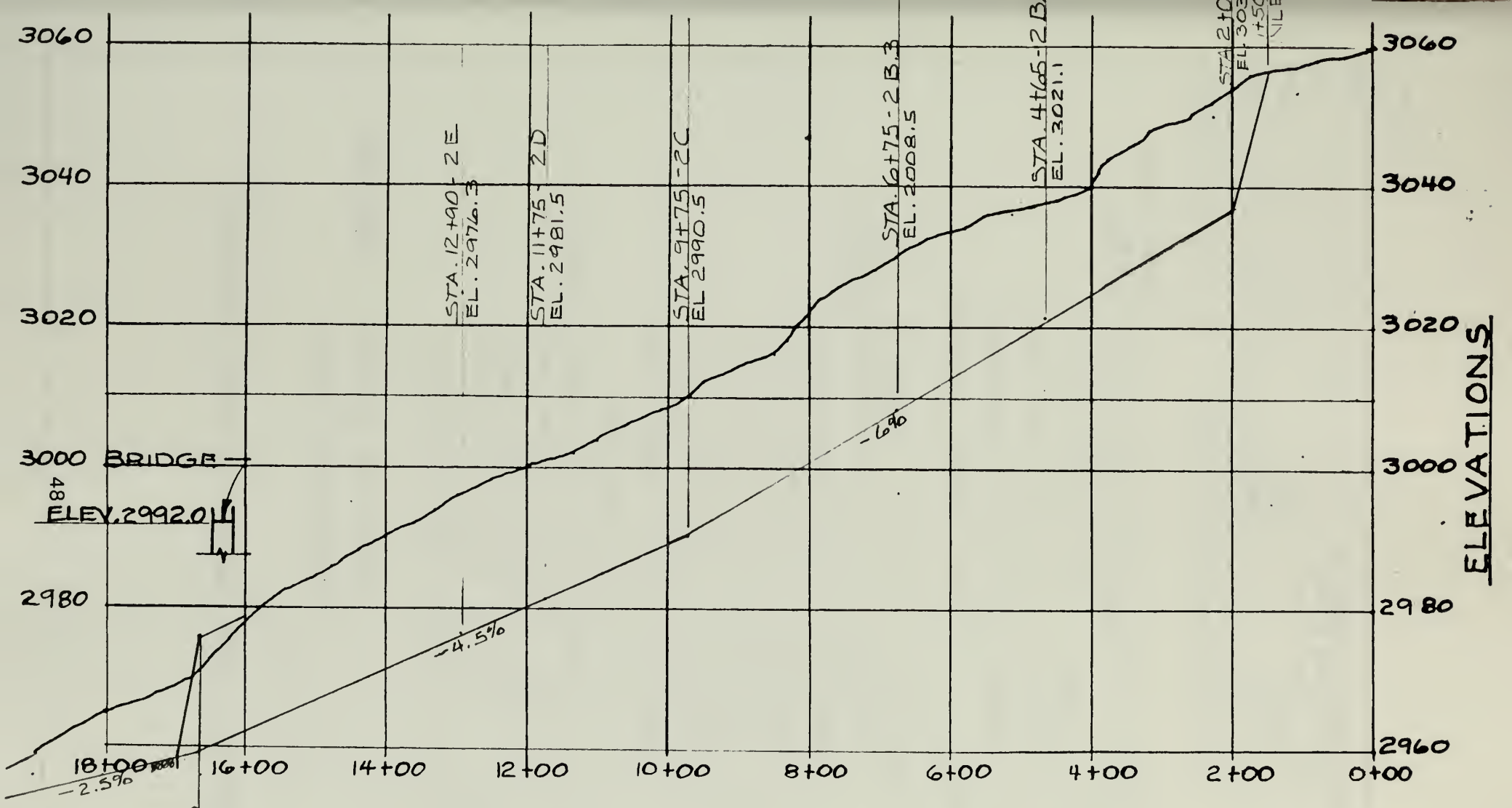
RETAINING WALL AROUND CAFE 88,700

TOTAL ALTERNATE B (NET) = $ 2,306,700
GROSS = NET x 1.31 = # 3,022,000

100 YEAR FLOOD - CONCRETE BOX CULVERT

•U.S. GPO: 1964-776-378


Alternative 'C'
Box Culvert
for Probable Maximum
Flood
CASTLE
3013.2
cafe
stable
BOX CULVERT
3074.2
3074.0
3008.5
Brush
SC
EL.3051.80
2991.2
2992.7
BM RM 6
EL. 2997.0
2970
Brush
2E
2D
2C
2B.3
2B.2
2B.1
SCOTTY'S CASTLE AREA
ALTERNATIVE C
STRUCTURAL MITIGATION
DEATH VALLEY NATIONAL MONUMENT
UNITED STATES DEPARTMENT OF INTERIOR/NATIONAL PARK SERVICE
N
SCALE 1":200'
143 | 40,110
DSC | AUG 89



PROFILE - STREAM BED

SCOTTY'S - CASTLE AREA

SCALE: AS INDICATED

ALTERNATIVE 'E'
@ PM BOX CULVERT

FORM D S C - 44

Park	DEATH VALLEY N M	NATIONAL PARK SERVICE DENVER SERVICE CENTER		Sheet 42
Area	SCOTTY'S CASTLE			of
Project	CASTLE AREA	By	Checked	Pkg.
Feature	ALT. C: @PM BOX CULVERT	Date	Date	Account

ALTERNATIVE C: QUANTITIES & COSTS:

BOX CULVERT

INLET: Diversion for Streambed Flow of 500CFS
21·110·1 = 85CY @ 300 = 26.000
Cutoff Wall = 100'x 1'x3' = 11 @ 450 = 5,000
Slab = (100+32)½(50) = 122 @ 450 = 55,000
Side Walls = (3+18)½(47) = 37 @ 500 = 18,500
Grate = 2000 S.F. @ $10 = 20,000
124.500

CONC. CULVERT (STA. 2+00 to 16+65) 120.7 @ 500 = 3,273,700

EXCAVATION: STA. 2+00 to 4+65 = 265(777)
STA. 4+65 to 6+75 = 210(893)
STA. 6+75 to 9+75 = 300(892)
STA. 9+75 to 11+75 = 200(861)
STA. 11+75 to 12+90 = 115(893)
STA. 12+90 to 15+50 = 260(819)
STA. 15+50 to 16+65 = 115(630)
45,235 C.Y. @ $20 = 904,700

OUTLET: Cutoff Wall: 42 x3x1 @ 500 = 2,350
Wing Walls: 2(356.5) @ 500 = 13,200
Slab: (32+42)½(30) @ 300 = 12,300
Riprap 42·100·3 @ 50 = 23,300
Excavation: 400(10)½·42 @ 20 = 62,200
$113,400

BRIDGE 34 x26 @ 115 / S.F. $101,700

TOTAL ALTERNATIVE C (NET) $4,518.000

GROSS = NET x 1.3 = $5,918.000

PROBABLE MAXIMUM FLOOD: BOX CULVERT

•U.S. GPO: 1984-778-378

Alternative D

This alternative consists of a corrugated metal pipe to carry the 100-year flood flow. A concrete inlet and outlet with headwalls, wingwalls, slabs, cutoff walls, and an inlet grate are necessary. Approximately 440 feet of earth channel, 36 feet wide, is required to provide an outlet grade of 2-1/2%. The first 100 feet of the earth channel will be lined with riprap to prevent erosion of the streambed and undermining of the culvert. The access road to the cafe parking requires some fill and repaving. At the culvert inlet, a diversion channel has been added to divert up to 500 cubic feet per second of the stream flow into the reconstructed streambed.

As in the other alternatives a retaining wall can be placed around the cafe protecting it from PMF if the cafe maintains sleeping quarters. This alternative assumes that the public will be protected from the probable-maximum flood by some non-structural means.

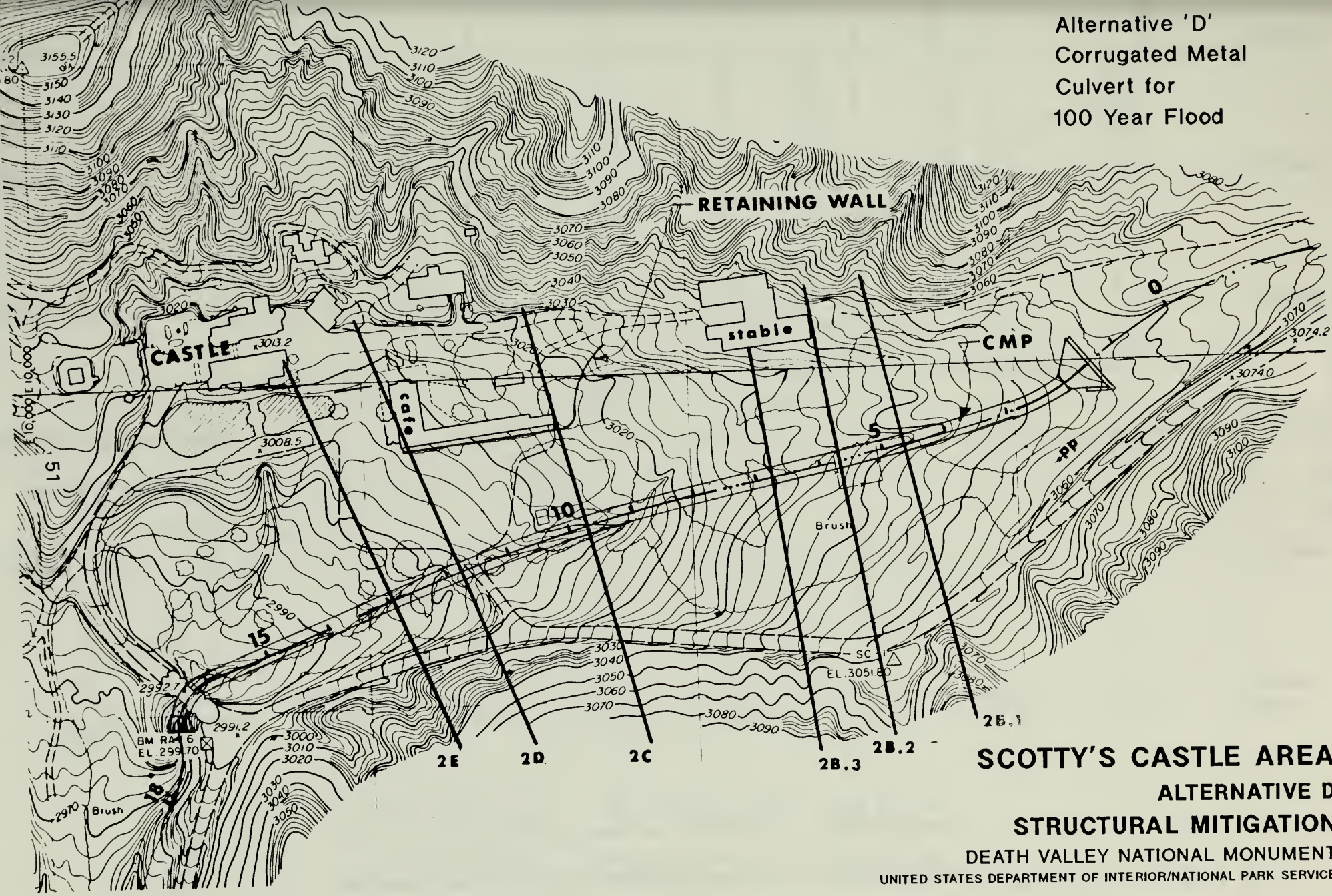
This alternative, as with the box culvert, will preserve the natural scene since the culvert will only be visible at the inlet and outlet structures and since normal stream flow will continue in a restored natural streambed.

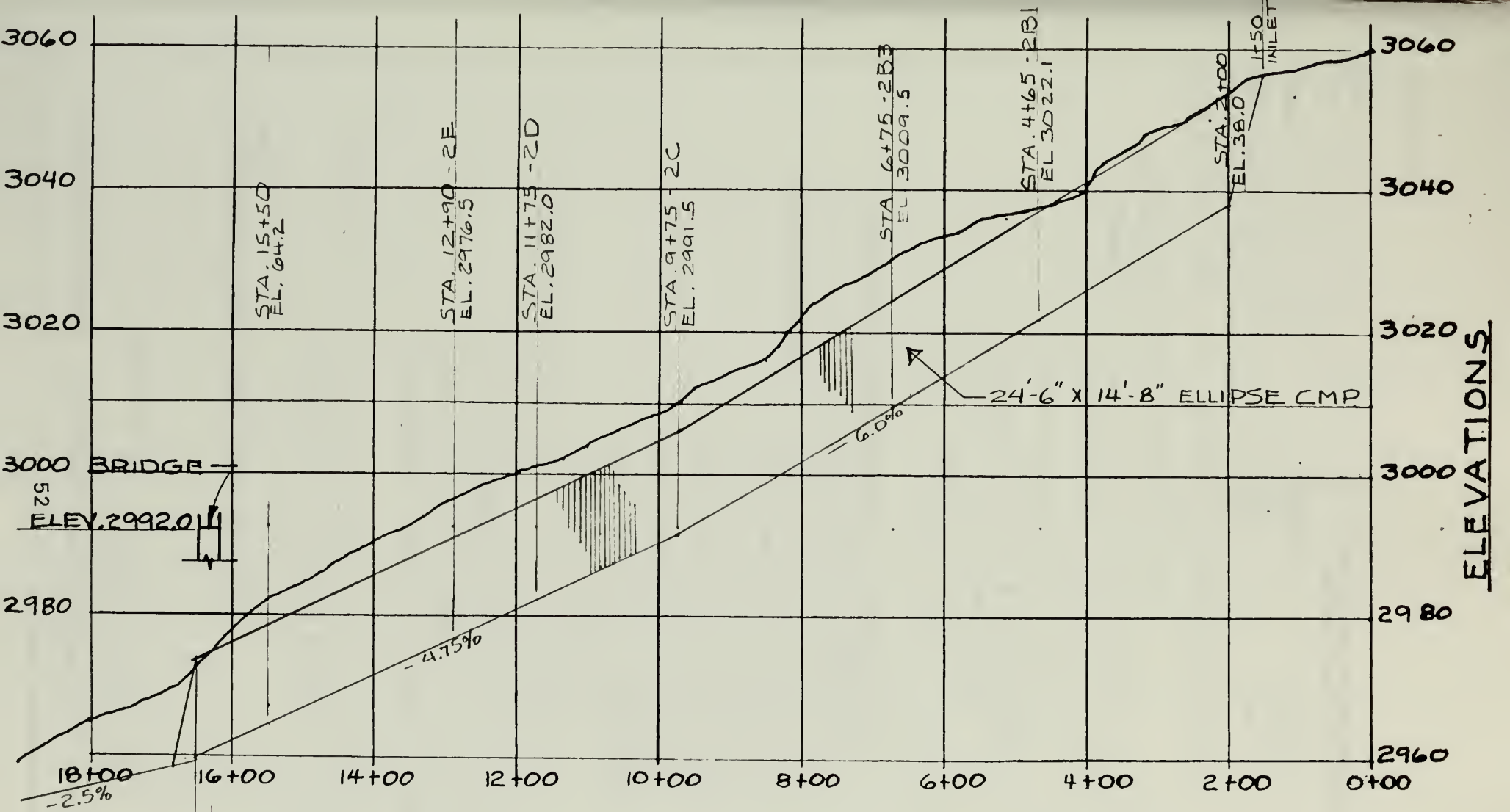
A plan and a profile are on the following two pages. Quantities and costs are given on page 53. Cost comparisons of the various alternatives are at the end of this section.

Other Alternatives Considered but Rejected

Alternative E would relocate the parking and picnic areas since they are in the 25-year to 100-year floodplain and are the visitor use facilities in the most hazard. There is an area out of the 100-year floodplain, but partially within the PMF floodplain where parking and picnicking could be relocated. It is shown on the graphic entitled Alternative E, Structural Mitigation. The relocated parking could be built on fill material to raise it above the PMF level. Fill slopes would be protected by gabions keyed in 2 feet vertically and 4 feet horizontally to prevent scouring. This relocation would greatly reduce the risk to visitors and property particularly if it is done in conjunction with the warning system described in alternative A.

There is an alternative relocation scheme for parking and picnicking, but much of the parking would be only above the 100-year floodplain and still within the PMF floodplain To mitigate the effects of the 100-year flood, the parking area below the cafe could be reconstructed on fill so that it is level north to south and sloping east to west to conform to the existing drainage. The reconstructed parking area would be 15,600 square feet smaller. The parking spaces lost by shortening the existing parking area would be furnished by an additional parking area located adjacent to the highway east of the cafe. Picnicking would also be relocated there and walkways would be developed between that area and the castle. The fill slope of the parking areas would be protected by gabions. The gabions would be keyed in 2 feet vertically and 4 feet horizontally to prevent scouring. Filter fabric would prevent the fill from being washed through the gabions and swept away. This alternative was rejected because of unacceptable visual impacts on the historic scene.


Alternative 'D'
Corrugated Metal
Culvert for
100 Year Flood
RETAINING WALL
CASTLE
3013.2
cafe
stable
CMP
3074.2
3074.0
3008.5
Brush
EL.3051.80
BM RA 6
EL. 2997.0
2991.2
2992.7
2970
Brush
2E
2D
2C
2B.3
2B.2
2B.1
SCOTTY'S CASTLE AREA
ALTERNATIVE D
STRUCTURAL MITIGATION
DEATH VALLEY NATIONAL MONUMENT
UNITED STATES DEPARTMENT OF INTERIOR/NATIONAL PARK SERVICE
N
SCALE 1":200'
143 | 40,111
DSC | AUG 89



PROFILE - STREAM BED

SCOTTY'S - CASTLE AREA

SCALE: AS INDICATED

ALTERNATIVE 'D'
Q100 CMP

FORM D S C - 44

Park DEATH VALLEY NM	NATIONAL PARK SERVICE DENVER SERVICE CENTER		Sheet 46
Area SCOTTY'S CASTLE			of
Project CASTLE AREA	By	Checked	Pkg.
Feature @100 CORRUG. METAL PIPE	Date	Date	Account

ALTERNATIVE D: QUANTITIES & COSTS:

CULVERT & APPURTENANCES

INLET: Diversion of 500 CFS (ALT. D) = 26,000⁻
Cutoff Wall = 100' x 1 x 3' @ 450 = 5000⁻
Slab = (100+29) ½ (50) @ 450 = 54,000⁻
Sidewalls = (18+3) ½ (62.5) @ 500 = 12,150⁻
Headwall = 26 x 18 x 1 @ 500 = 8,850⁻
Grate = 450 S.F. @ $10 = 4,500⁻

$ 110,500

24'-6" X 14'-8" HORIZONTAL ELLIPSE CMP
Sta. 2+00 to 16+50 @ $800 / Ft. = 1,160,000

EXCAVATION STA. 2+00 to 4+65 = 265 (561)
" 4+65 to 6+75 = 210 (627)
" 6+75 to 9+75 = 300 (660)
" 9+75 to 11+75 = 200 (627)
" 11+75 to 12+90 = 115 (644)
" 12+90 to 16+50 = 360 (595)
33,033 yd³ @ $20⁻ = 660,700

OUTLET Cutoff wall: 36 x 3 x 1 @ 500 = 2,000
Wing Walls: 2 (403) @ 500 = 15,000
Slab: (27+36) ½ · 30 @ 450 = 15,750
Riprap: 36 x 99 x 3 @ 50 = 19,800
Excavation: 440 (111½ (36) @ 20 = 64,500

117,100

BRIDGE (32 ft. x 2)(150) = 400 C.Y. fill @ 15 = 6000
Pavement: 150 x 20 x ¼ x 30/S.Y. = 10,500

16,500

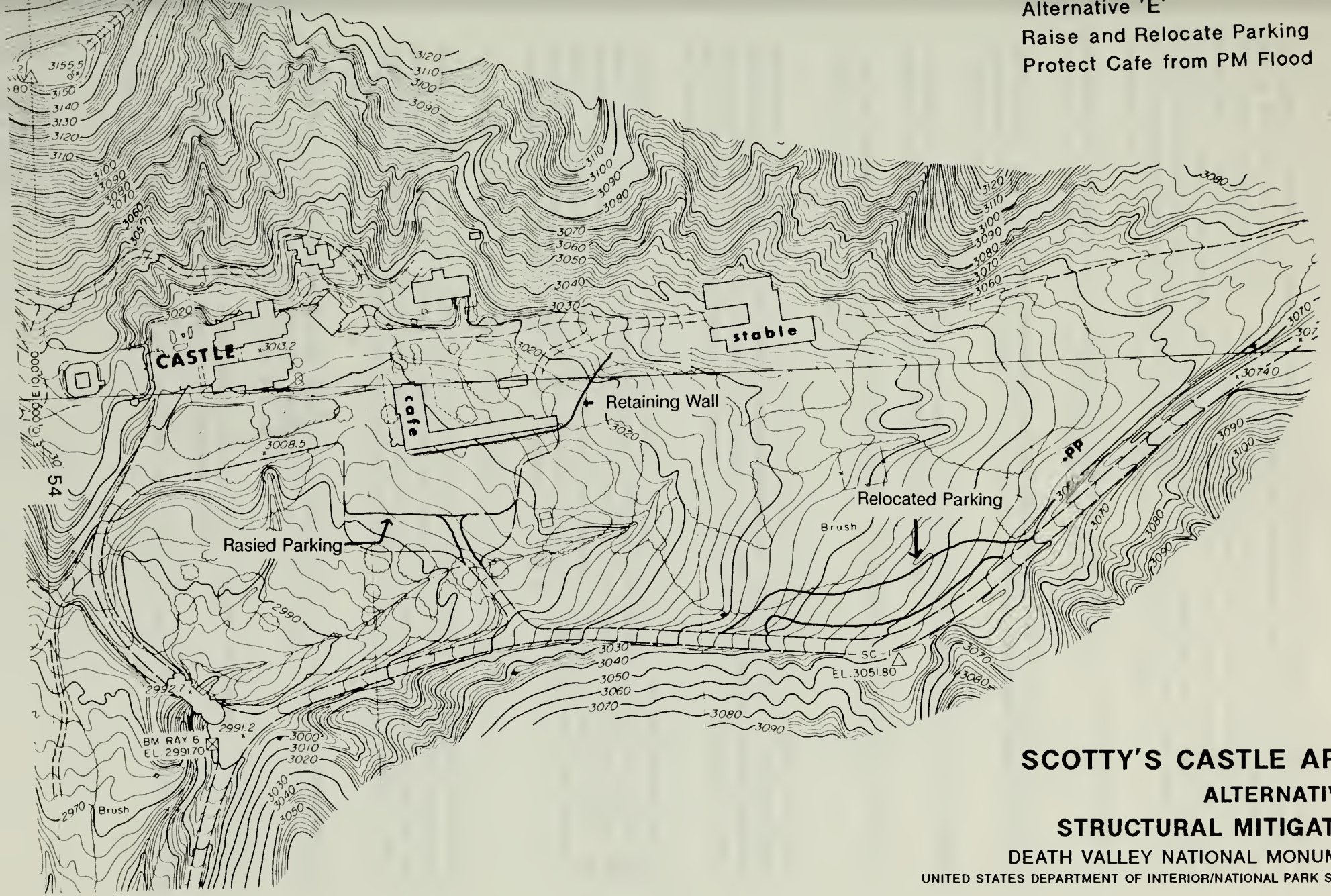
PMF
RETAINING WALL AROUND CAFE

88,700

TOTAL ALTERNATIVE D (NET) $ 2,153,500⁻
GROSS = NET x 1.31 = 2,821,000⁻

100 YEAR FLOOD - CORRUGATED METAL PIPE CULVERT

*U.S. GPO: 1984-778-378



SCOTTY'S CASTLE AREA

ALTERNATIVE E

STRUCTURAL MITIGATION

DEATH VALLEY NATIONAL MONUMENT

UNITED STATES DEPARTMENT OF INTERIOR/NATIONAL PARK SERVICE

N

SCALE 1":200'

143	40,116
DSC	AUG 89

Alternative F is similar to Alternative E and consists of raising the cafe parking area to protect the parking from the 100-year flood. The parking area fill is supported and protected by a retaining wall, rather than the gabions in Alternative E. The lost parking space of 1700 square yards can be added to the south side of the canyon. As in Alternative E, the embankment for the replacement parking is supported and protected by gabions. This alternative would also require raising the parking access road about three feet on one end. A retaining wall to protect the cafe from the probable-maximum flood can also be added. This alternative assumes that protection of the public from the probable-maximum flood will be by non-structural means.

Alternative F1 is defined as the raised cafe parking area protected from the 100-year flood with or without the retaining wall for the PMF protection for the cafe.

Alternative F2 is defined as the raised cafe parking area protected from the 100-year flood and the replacement parking on the south side of the canyon with or without the retaining wall for the PMF protection for the cafe.

It is proposed to place a rock veneer or stucco on the face of the retaining wall(s). This will help preserve the character of the area with matching construction.

A plan of Alternative F is given on the following page. This alternative was rejected due to high visual impact on the historic scene.

Alternative G consists of a concrete channel to carry the 100-year flood. An inlet structure is required and a flared outlet with riprap to prevent streambed erosion is needed. A 30-foot bridge for the access road to the cafe parking is necessary. A retaining wall for the probable maximum protection for the cafe can be added. Protection of the public from the PMF is assumed to be by non-structural means.

The concrete channel is 10 feet wide at the bottom to facilitate cleaning with equipment, and the sides are constructed at a 1 on 2 slope to allow crossing by, and to prevent injury to, animals and humans. The overall width of the channel is 39 feet; so, the channel will occupy only a small portion of the canyon floor, visual impact would be reduced if colored concrete is used. The character of a mountain streambed will obviously not remain since the scene will include a man-made channel. A plsn of the channel is shown on page 57.

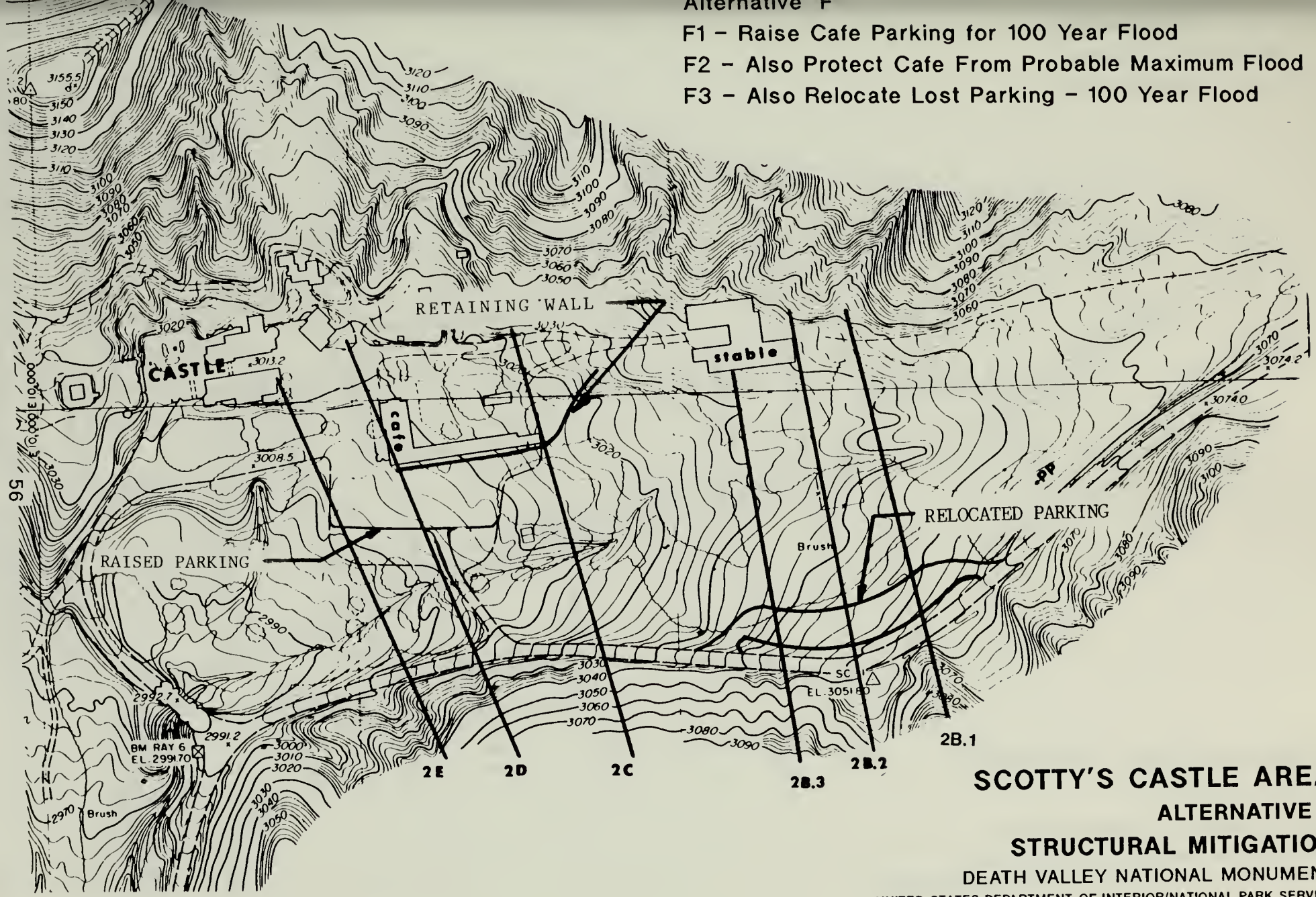
This alternative was also rejected for visual impacts on the historic scene.

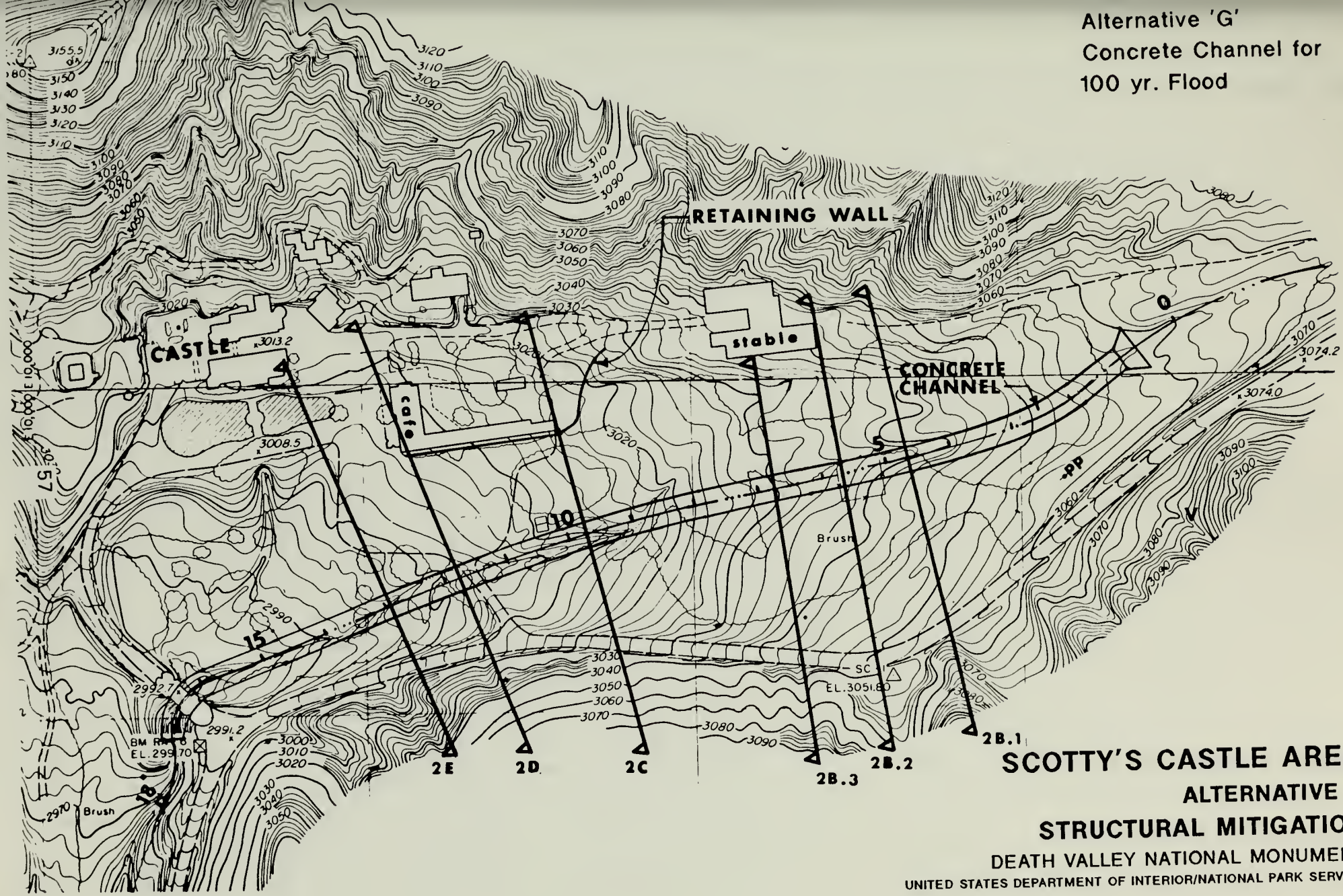
Alternative H consists of a concrete channel for the probable maximum flood. Inlet and outlet structures are required. Riprap is needed at the outlet to prevent stream bed erosion and undermining of the outlet structure. A 60-foot bridge for the access road to the cafe parking area is necessary. The trapezoidal channel transitions to a rectangular channel at the bridge to reduce the required bridge span.

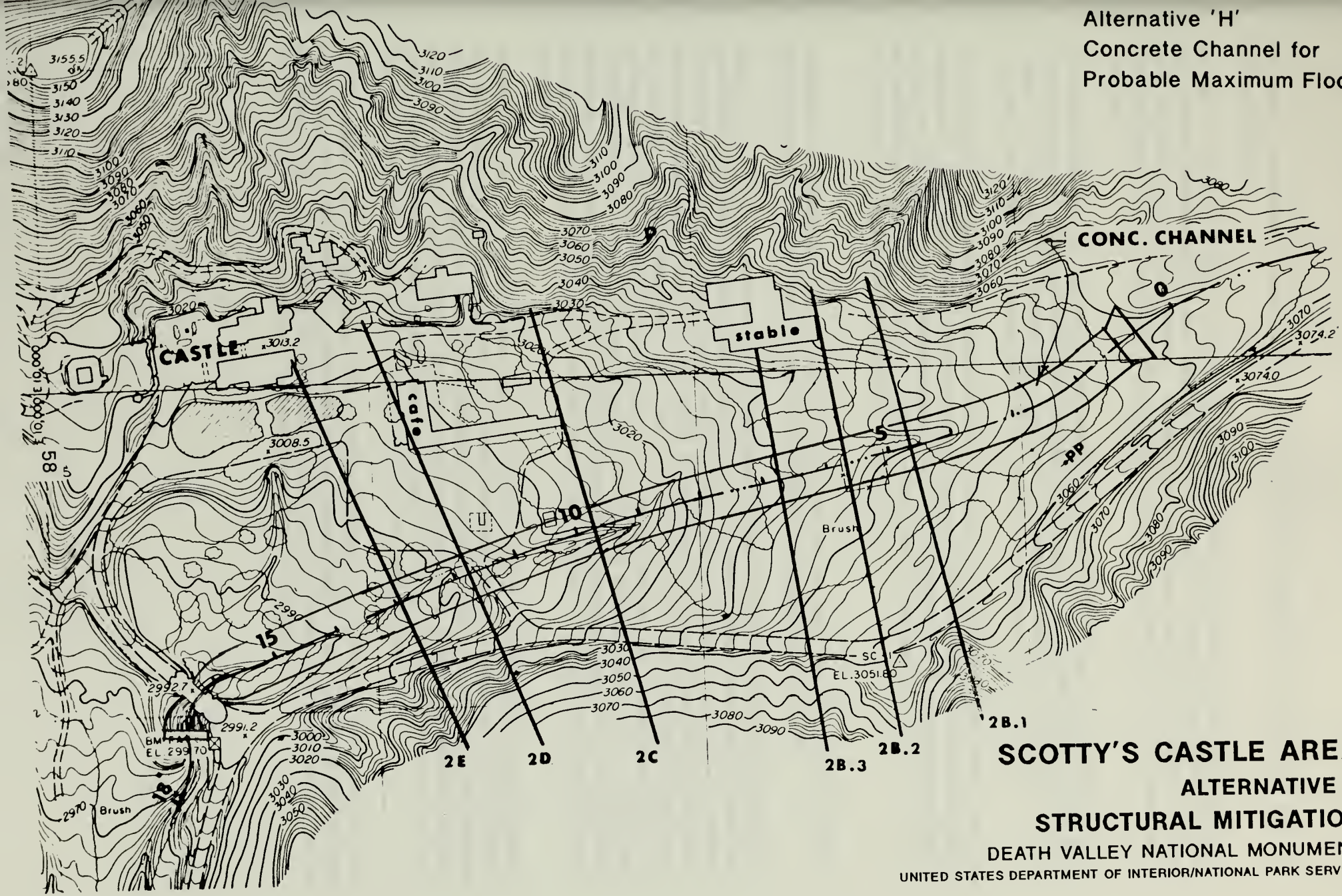
The bottom of the channel is 40 feet wide and the total depth is 8.75 feet. The channel has side slopes of 1 on 2 to prevent injury and trapping of animals and humans. The overall width is 75 feet. A plan of the channel is shown on page 58.

Even with colored concrete, this large a channel will be readily noticeable since the entire streambed proper will be replaced with a concrete facility.

As with alternatives F and G this alternative was rejected due to unacceptable visual impact on the historic scene.


Alternative F
F1 – Raise Cafe Parking for 100 Year Flood
F2 – Also Protect Cafe From Probable Maximum Flood
F3 – Also Relocate Lost Parking – 100 Year Flood
RETAINING WALL
CASTLE
cafe
stable
RAISED PARKING
RELOCATED PARKING
Brush
BM RAY 6
EL. 299170
2E
2D
2C
2B.3
2B.2
2B.1
SCOTTY'S CASTLE AREA
ALTERNATIVE F
STRUCTURAL MITIGATION
DEATH VALLEY NATIONAL MONUMENT
UNITED STATES DEPARTMENT OF INTERIOR/NATIONAL PARK SERVICE
N
SCALE 1":200'
143 | 40,112
DSC | AUG 89


Alternative 'G'
Concrete Channel for
100 yr. Flood
RETAINING WALL
CASTLE
3013.2
cafe
stable
CONCRETE
CHANNEL
3074.2
3074.0
3008.5
Brush
SC
EL.3051.80
2992.7
2991.2
BM
EL.299.70
2E
2D
2C
2B.3
2B.2
2B.1
SCOTTY'S CASTLE AREA
ALTERNATIVE G
STRUCTURAL MITIGATION
DEATH VALLEY NATIONAL MONUMENT
UNITED STATES DEPARTMENT OF INTERIOR/NATIONAL PARK SERVICE
N
SCALE 1":200'
143 | 40,113
DSC | AUG 89


Alternative 'H'
Concrete Channel for
Probable Maximum Flood
CONC. CHANNEL
CASTLE
cafe
stable
Brush
Brush
SC
EL.3051.80
BM
EL. 2997.0
2E
2D
2C
2B.3
2B.2
2B.1
SCOTTY'S CASTLE AREA
ALTERNATIVE H
STRUCTURAL MITIGATION
DEATH VALLEY NATIONAL MONUMENT
UNITED STATES DEPARTMENT OF INTERIOR/NATIONAL PARK SERVICE
N
SCALE 1":200'
143 | 40,114
DSC | AUG 89

Alternative I considered a diversion for a portion of Upper Grapevine Canyon drainage into Tie Canyon drainage.

The graphic entitled Alternative I, Drainage Diversion indicates the extent of the SC-2 drainage area for Grapevine Canyon which can be diverted into Tie Canyon(SC-1). The area to be diverted occurs above the Diversion Dike. New times of concentration were determined for the various new and combined areas. Also 100-year and probable maximum precipitation and runoff for the areas were determined.

The diversion reduced the 100-year runoff from 8500 CFS to 6300 CFS, about the capacity of one of the four culverts. The probable maximum runoff was reduced from 36,400 CFS to 27,500 CFS or about 1 1/2 feet on the diversion dike. The cost of a diversion dike for the 100-year runoff is $379,000. The cost of a diversion dike for the probable maximum runoff is $727,500.

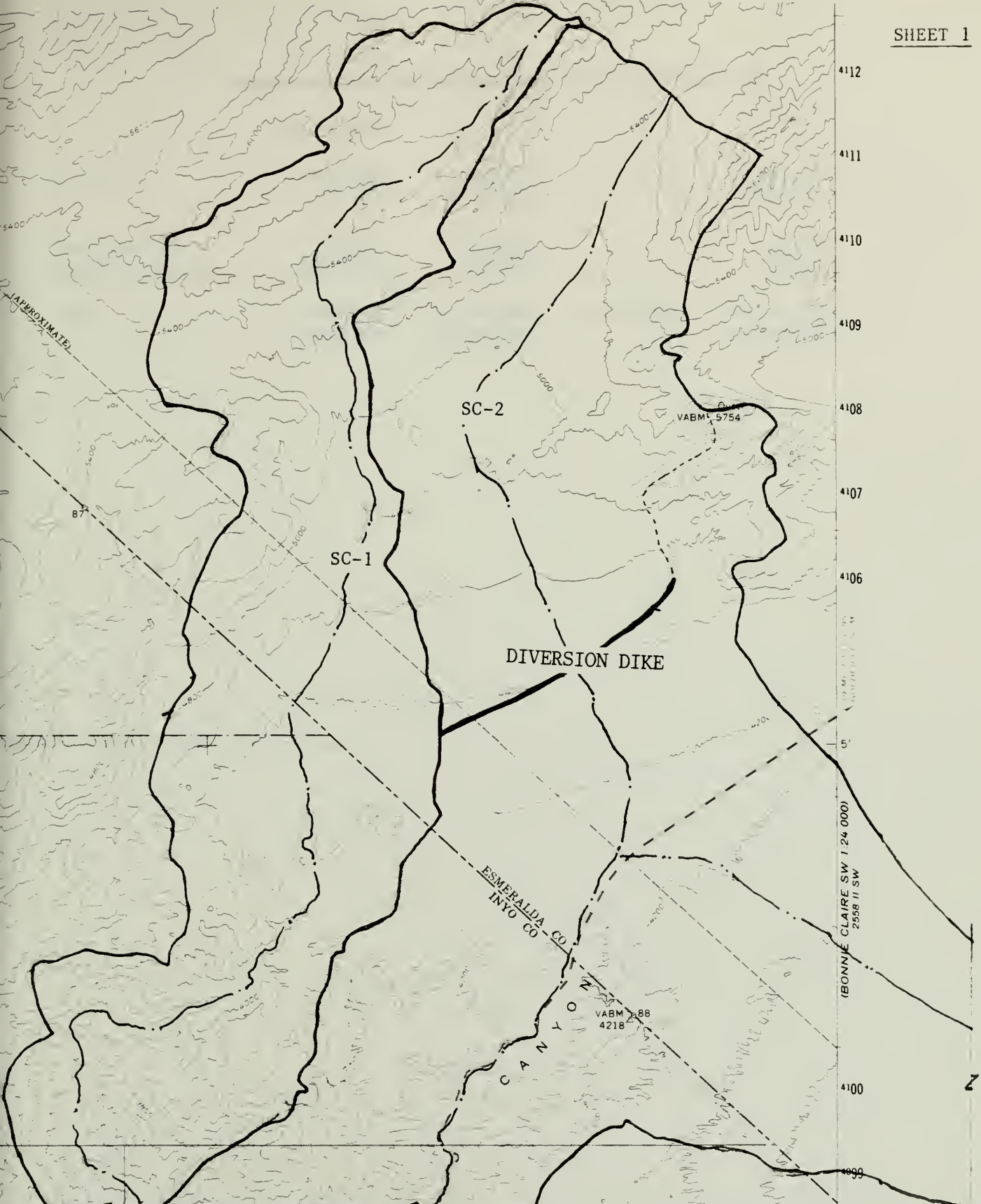
This alternative was rejected for several reasons. The costs of handling the runoff within Scotty's Castle area is much less than the drainage diversion costs. The flow is reduced only about 25% for both the 100-year and the probable maximum floods. Maintenance costs would have to include the rebuilding of the dike every two years or so due to sediment from minor flooding. Environmental consequences would require extensive study.

Alternative J considered a different type of warning system that could be applied to the Scotty's Castle situation. A description of it and its advantages and disadvantages follows.

Stream flow monitoring gauges or gauges that simply indicate water has reached their level could be installed in Grapevine Canyon wash bottom above the castle. Flood flows could be expected to move 9 to 15 miles per hour down the wash (for 100-year to PMF flows), and to obtain warning from stream flow gauges they could be placed at intervals in the wash bottom above the castle. For example, if placed upstream 1 mi, 2 mi., 4 mi., and in each major tributary above there, warning times of 4.5 to 20 minutes or more could be obtained depending on where the rainfall was within the drainage. While 4.5 minutes is not much time for an evacuation; it may be adequate since only the parking lot and picnic area would have to be evacuated, and most visitors should have already been informed about what to do during an evacuation. Five to seven gauges would be needed.

Depending on what is desired of this type of warning system, the gauges could transmit by radio to a computer and terminal in the dispatch office that could alert the dispatcher or automatically set off alarms at the castle. Multi-level gauges could indicate the flood flow level so the computer could calculate the expected flood level, or they could be simpler single-level gauges that only indicate if the flood flow has reached their level (their level being determined by the level of flood that you have decided in advance is large enough for the alarms to sound).

This alternative was rejected because of an inherent disadvantage of this type of system, i.e. that the gauges are in the wash bottoms where they are susceptible to being destroyed by the force of a major flood. This problem is a significant drawback for a system that must function during the flood event, and engineered structural reinforcement is mandatory.



SCOTTY'S CASTLE AREA

ALTERNATIVE I

DRAINAGE DIVERSION

DEATH VALLEY NATIONAL MONUMENT

UNITED STATES DEPARTMENT OF INTERIOR/NATIONAL PARK SERVICE

N

SCALE 1:62,500

143	40,115
DSC	AUG 89

SUMMARY OF ALTERNATIVES AND COST COMPARISONS

	A (preferred)	B	C	D
Sturctural	$558,000 - 583,500	$3,055,000 - 3,081,000	$5,977,000	$2,854,500 - 2,880,000
Non-Stuctural (warning system)	90,000 - 205,5000	90,000 - 205,500		90,000 - 205,000
Total	$648,000 - $789,000	$3,145,000 - $3,286,500	$5,977,000	$2,944,500 - $3,085,500

ENVIRONMENTAL CONSEQUENCES

Depending on which environmental components were affected, the Volume III study evaluated all or some of the following eight impact topics for each of the areas prone to flood hazard: Soils; Scenic Quality; Natural and Beneficial Values of Floodplains; Endangered, Threatened, or Endemic Species; Historic Resources; Timbisha-Shoshone Village; Public Safety; and Public Property. Actions at Scotty's Castle will not affect the Timbisha-Shoshone village so that topic will not be evaluated. The topics of Public Safety and Property will be combined and all other impact topics listed above will be evaluated.

Two additional topics of potential concern are archaeological resources and the Desert tortoise (Gopherus agassizii). The project area was surveyed for archaeological resources in 1990 by George Teague of the Western Archeological an Conservation Center (WACC) and Jan Lawson, DEVA staff archaeologist. Most of the project will occur in active or altered washes, where no evidence of resources was found. This evironmental assessment is being transmitted to WACC for a written archelogical clearance.

Since the USFWS has recently proposed listing the Desert tortoise as a Threatened Species all actions which could affect it are of concern. Its' range however only extends into the southern quarter of the monument. There has been only one recorded observation of the tortoise at Scotty's Castle and that occurred in the 1960's. It is quite possible with the high visitation to the Castle that the observation was the result of a visitor release in the area. There have been no repeat observations since that time, so the Desert tortoise was not evaluated as an impact topic.

NO ACTION

Since there will be no changes made under the no action alternative, there will be no effect on soils, scenic quality, natural and beneficial values of floodplains, and endangered, threatened or endemic species.

Impact on Historic Resources

The 100 year flood would probably destroy the entrance bridge structure. The probable maximum flood would destroy five of the six historic structures listed below and would cause some damage to the stables.

Impact on Public Safety and Property

Under the no action alternative 270 people during the day and 10 people at night would be in the probable maximum floodplain without structural protection. Potential property loss in the Scotty's Castle area, if left unprotected by structural mitigation measures and vulnerable to flood damage or destruction, is as follows:

Development	Existing Conditions/Structure[1] 100-Year	PMF
Scotty's Castle Area		
Services and Lodging		
Dining Room and Curio Shop *		8,119 S.F.
Restroom *		528 S.F.
Stables *		10,504 S.F.
Service Station Building *	36 S.F.	
Ticket Office		80 S.F.
Housing		
Bridge Apartment *	578 S.F.	
Utilities		
Storage Building *		180 S.F.
Chlorinator House	104 S.F.	
Spring House	752 S.F.	

1. Structures listed in the 100-year floodplain column are also included under PMF.
* Historic Structures

In the event of a 100-year flood, replacement costs for the four facilities listed above would be $447,500. The PMF would destroy all facilities listed above and the replacement cost would be $3,521,500. There is no cost for flood mitigation in this alternative.

ALTERNATIVE A (PREFERRED)

Impact on Soils

Flood mitigation measures in this alternative would create the following disturbances:

Cafe retaining wall = 9,225 - 12,300 sq. ft.
Diversion dike = 26,950 sq. ft.
Entrance bridge culverts = 12,712 sq. ft.
Water intake dike = 20,700 sq. ft.

Total disturbance for this alternative would be 1.6 - 1.7 acres in previously disturbed areas.

Impact on Scenic Quality

In the Water Intake area the two dikes to protect the water system are below the highway, constructed of natural materials and screened by vegetation; they will have minimal visual intrusion to visitors traveling the highway.

In the Scotty's Castle area, the four foot high retaining wall which will protect the cafe will be visible but will be constructed of the same surface materials as the cafe so that it will blend in with the architecture of that building. Since the wall was not in place in 1954 it will be a visual impact on the historic scene from that era. However, as shown in photograph four, the wall will cover everything below the window line of the cafe building and thereby hide the utilities entering the structure which may also not have been part of the 1954 historic scene.

The large dike will be placed in the same location as an existing dike which is presently hidden from view by vegetation currently in place. Since this vegetation is quite large, it willl hide the new dike even though that dike will be substantially larger than the existing dike. Therefore, no impact on the scenic quality of the area is expected.

Potentially the most significant visual impacts to the area could come from the four culverts to protect the entrance bridge structure. Each of the culverts would be 15.3 feet wide by 9.2 feet high and they would be placed northwest of the bridge under the existing roadway. Visual impact would be greater on the upper or castle side of the roadway. The lower or exit end of the culvert would be out of the Scotty's Castle historic scene and far enough below the grade of the roadway that they should not be visible to visitors traveling on the highway. Screening the upper end of the culverts with vegetation, is possible but such screening would need to be large enough to hide the culverts yet small enough so it wouldn't plug them up in the event of a flood. Other options considered to reduce the visual impact are discussed under the alternative description on page 27. If the visual impact of the culverts is considered too severe one of these options may need to be selected.

Impact on Natural and Beneficial Values of Floodplains

Under this alternative the natural functioning of the floodplain will be altered in both the Water Intake and Scotty's Castle areas. In the Water Intake area the floodplain has been altered by the dikes which are already there to protect the water system. These dikes would be reinforced and enlarged so that the present 1 - 2 acres of floodplain which is presently affected would be expanded to 3 - 4 acres of 100-year floodplain affected. PMF flows would overflow these dikes in the natural floodplain. Since these dikes would be employed in alternatives A - D, the impacts would be the same in all four alternatives.

The floodplain has been altered in the Scotty's Castle area as well, both from the dikes currently in place to protect the development, and from the development itself. The new dike would be a strengthening, improvement, and enlargement upon the existing dike. These improvements will essentially permanently

remove the development below the dike from the natural floodplain, particularly if the option to protect the cafe from the PMF is selected. However, since this area is already altered by development it is not presently natural floodplain. Once floodflows passed the development and its structural protection they would again be returned to the natural floodplain.

Total alteration of the previously disturbed floodplain would be about 15 - 20 acres in this alternative.

Impact on Endangered, Threatened, or Endemic Species

Development of structural mitigation measures would take place within the range of the following three plant species:

Plant	USFWS CATEGORY	ENDEMIC CLASS	KNOWN HABITAT (acres)	MONUMENT HABITAT AFFECTED (acres)
Arctomecon merriamii	III-C	III	17,800	1.6-1.7
Boerhaavia annulata	-	II	41,380	1.6-1.7
Camissonia claviformis funerea	-	II	30,760	1.6-1.7

Impact on Historic Resources

All historic structures would be protected to the 100-year flood level in this alternative. The six historic structures would be subject to damage or destruction from the PMF unless the protective wall was added in which case all historic structures would be safe except for the stables.

The impacts on the historic scene are discussed in the section on Impact on Scenic Quality.

Impact on Public Safety and Property

The threat to life would be reduced by an unknown amount in this alternative. The design of the dike will allow PMF flows around the lower end creating a hazard to people in the cafe and parking area. If the cafe is protected with a PMF wall, the number of people subject to the hazards of PMF flows will be substantially reduced. Potential property loss in the Scotty's Castle area, if left unprotected by structural mitigation measures and vulnerable to flood damage or destruction, is as follows:

Development	Existing Conditions/Structure[1] 100-Year	PMF
Scotty's Castle Area		
Services and Lodging		
Dining Room and Curio Shop *		8,119 S.F.
Stables *		10,504 S.F.
Service Station Building *	36 S.F.	
Ticket Office		80 S.F.
Housing		
Bridge Apartment *		578 S.F.
Utilities		
Storage Building *		180 S.F.
Chlorinator House		104 S.F.
Spring House		752 S.F.

1. Structures listed in the 100-year floodplain column are also included under PMF.
* Historic structures - storage building is in castle area.

Although the dike would be designed to withstand PMF flows, the 100-year flood would likely flow around the end of the dike destroying the gas station. Replacement costs for this facility would be $63,000. The replacement cost for those facilities damaged or destroyed by the PMF would be $3,409,500. Flood mitigation costs would be $558,000 for structural mitigation and between $90,000 and $205,500 for nonstructural mitigation.

If the option to protect the Cafe to the PMF were selected structural flood mitigation costs would increase by $25,500 to $583,500 and replacement costs for property losses would decrease by $1,298,500 to $2,111,500.

ALTERNATIVE B

Impact on Soils

Flood mitigation measures in this alternative would create the following disturbances:

Intake area = 8,250 sq. ft.
Outlet area = 11,850 sq. ft.
Culvert = 82,500 sq. ft.
Water intake = 20,700 sq. ft.

Total disturbance for this alternative would be 2.8 acres in previously disturbed areas.

Impact on Scenic Quality

The impacts from construction of the dikes in the Water Intake area and from the retaining wall to protect the cafe would be the same as those described in alternative A.

Since the box culvert would be entirely underground the only visual impacts would be from the entance and exit structures. As also discussed under the impacts of the culverts to protect the bridge in alternative A, the visual impact of the lower or exit end of the culverts will be very low. The same will be true of the exit end of the box culvert, which should be out of the Scotty's Castle historic scene and far enough below the grade of the roadway so that it will not be visible to visitors traveling on the highway. The entrance structure at the upper end of the box culvert, since it is located so far upstream, and is well screened by vegetation, will also not be part of the Scotty's Castle historic scene and should not be visible to visitors.

Impact on Natural and Beneficial Values of Floodplains

Under this alternative the natural functioning of the floodplain will be altered in both the Water Intake and Scotty's Castle areas. The impacts from the structural flood mitigation measures in the Water Intake area would be the same as in alternative A.

As discussed in alternative A, the floodplain has been altered in the Scotty's Castle area as well both from the dikes currently in place to protect the development and from the development itself. The new channel would remove all flows of the 100-year or lower magnitude from the already altered floodplain within the developed area. Flows would be returned to the natural floodplain below the developed area. PMF flows will overflow the channel and occupy the normal floodplain within and below the development.
Total alteration of the previously disturbed 100-year floodplain would be about 10 - 15 acres in this alternative. The PMF floodplain would not be affected.

Impact on Endangered, Threatened, or Endemic Species

Development of structural mitigation measures would take place within the range of the following three plant species:

Plant	USFWS CATEGORY	ENDEMIC CLASS	KNOWN MONUMENT HABITAT HABITAT (acres)	AFFECTED (acres)
Arctomecon merriamii	III-C	III	17,800	2.8
Boerhaavia annulata	-	II	41,380	2.8
Camissonia claviformis funerea	-	II	30,760	2.8

Impact on Historic Resources

All historic structures would be protected to the 100-year flood level in this alternative. The six historic structures would be subject to damage or destruction from the PMF unless the protective wall was added in which case all historic structures would be safe except for the stables.

The impacts on the historic scene are discussed in the section on Impact on Scenic Quality.

Impact on Public Safety and Property

Under this alternative the number of people in the probable maximum floodplain without structural protection would remain the same as no action 270 during the day and 10 at night. Potential property loss in the Scotty's Castle area, if left unprotected by structural mitigation measures and vulnerable to flood damage or destruction, is as follows:

Development	Existing Conditions/Structure[1] 100-Year	PMF
Scotty's Castle Area		
Services and Lodging		
Dining Room and Curio Shop *		8,119 S.F.
Restroom *		528 S.F.
Stables *		10,504 S.F.
Service Station Building *		36 S.F.
Ticket Office		80 S.F.
Housing		
Bridge Apartment *		578 S.F.
Utilities		
Storage Building *		180 S.F.
Chlorinator House		104 S.F.
Spring House		752 S.F.

1. Structures listed in the 100-year floodplain column are also included under PMF.
* Historic

All the above facilities would be protected to the 100-year flood level but subject to damage from the PMF. The replacement cost for these facilities would be $3,521,500. Flood mitigation costs would be $3,055,000 for structural mitigation and between $90,000 and $205,500 for nonstructural mitigation.

As in alternative A if the option to protect the Cafe to the PMF were selected structural flood mitigation costs would increase by $25,500 to $3,081,000 and replacement costs for property losses would decrease by $1,311,500 to $2,211,000.

ALTERNATIVE C

Impact on Soils

Flood mitigation measures in this alternative would create the following disturbances:

Intake area = 9,380 sq. ft.
Outlet area = 24,960 sq. ft.
Culvert = 114,000 sq. ft.
Water intake = 20,700 sq. ft.

Total disturbance for this alternative would be 3.9 acres in previously disturbed areas.

Impact on Scenic Quality

The impacts from construction of the dikes in the Water Intake area would be the same as those described in alternative A.

As in alternative B, since the box culvert would be entirely underground the only visual impacts would be from the entrance and exit structures. As also discussed under the impacts of alternative B, the visual impact of the lower or exit end of the box culvert will be very low. The same will be true of the exit end of the PMF box culvert, although the exit structure will be longer and morte noticeable than in Alternative B, it should still be out of the Scotty's Castle historic scene and far enough below the grade of the roadway so that it will not be visible to visitors traveling on the highway. As in alternative B, the entrance structure at the upper end of the box culvert, since it is located so far upstream, and is well screened by vegetation, will also not be part of the Scotty's Castle historic scene and should not be visible to visitors.

Impact on Natural and Beneficial Values of Floodplains

Under this alternative the natural functioning of the floodplain will be altered in both the Water Intake and Scotty's Castle areas. The impacts from the structural flood mitigation measures in the Water Intake area would be the same as in alternative A.

As discussed in alternative A, the floodplain has been altered in the Scotty's Castle area as well both from the dikes currently in place to protect the development and from the development itself. The new channel would remove all flows of the PMF or lower magnitude from the already altered floodplain within the developed area. Flows would be returned to the natural floodplain below the developed area.

Total alteration of the previously disturbed PMF floodplain would be about 15 - 20 acres in this alternative.

Impact on Endangered, Threatened, or Endemic Species

Development of structural mitigation measures would take place within the range of the following three plant species:

Plant	USFWS CATEGORY	ENDEMIC CLASS	KNOWN MONUMENT HABITAT (acres)	HABITAT AFFECTED (acres)
Arctomecon merriamii	III-C	III	17,800	3.9
Boerhaavia annulata	-	II	41,380	3.9
Camissonia claviformis funerea	-	II	30,760	3.9

Impact on Historic Resources

All historic structures would be protected in this alternative.

The impacts on the historic scene are discussed in the section on Impact on Scenic Quality.

Impact on Public Safety and Property

Under this alternative the number of people who would be in the probable maximum floodplain without structural protection both day and night would be reduced to 0. Potential property loss in the Scotty's Castle area, if left unprotected by structural mitigation measures and vulnerable to flood damage or destruction, is as follows:

Development	Existing Conditions/Structure 100-Year	PMF
Utilities		
Chlorinator House		104 S.F.
Spring House		752 S.F.

All facilities in the Castle area would be protected to the PMF. In the water intake area facilities would be protected to the 100-year flood but subject to damage or loss from the PMF. The replacement cost for these facilities would be $135,500. Flood mitigation costs would be $5,977,000 for structural mitigation and between $90,000 and $205,500 for nonstructural mitigation.

ALTERNATIVE D

Impact on Soils

Flood mitigation measures in this alternative would create the following disturbances:

Intake area = 7,800 sq. ft.
Outlet area = 3,890 sq. ft.
Culvert = 114,000 sq. ft.
Water intake = 20,700 sq. ft.

Total disturbance for this alternative would be 3.4 acres in previously disturbed areas.

Impact on Scenic Quality

The impacts from construction of the dikes in the Water Intake area and from the retaining wall to protect the cafe would be the same as those described in alternative A.

Since the only major difference between this alternative and alternative B is the type of culvert that will be placed underground, the visual impacts of this alternative will be the same as those discussed in that alternative.

Impact on Natural and Beneficial Values of Floodplains

The impacts of this alternative would be the same as in alternative B.

Impact on Endangered, Threatened, or Endemic Species

Development of structural mitigation measures would take place within the range of the following three plant species:

Plant	USFWS CATEGORY	ENDEMIC CLASS	KNOWN HABITAT (acres)	MONUMENT HABITAT AFFECTED (acres)
Arctomecon merriamii	III-C	III	17,800	3.4
Boerhaavia annulata	-	II	41,380	3.4
Camissonia claviformis funerea	-	II	30,760	3.4

Impact on Historic Resources

All historic structures would be protected to the 100-year flood level in this alternative. The six historic structures would be subject to damage or destruction from the PMF unless the protective wall was added in which case all historic structures would be safe except for the stables.

The impacts on the historic scene are discussed in the section on Impact on Scenic Quality.

Impact on Public Safety and Property

Under this alternative the number of people in the probable maximum floodplain without structural protection would remain the same as no action 270 during the day and 10 at night. Potential property loss in the Scotty's Castle area, if left unprotected by structural mitigation measures and vulnerable to flood damage or destruction, is as follows:

Development	Existing Conditions/Structure[1]	
	100-Year	PMF
Scotty's Castle Area		
Services and Lodging		
Dining Room and Curio Shop *		8,119 S.F.
Restroom *		528 S.F.
Stables *		10,504 S.F.
Service Station Building *		36 S.F.
Ticket Office		80 S.F.
Housing		
Bridge Apartment *		578 S.F.
Utilities		
Storage Building *		180 S.F.
Chlorinator House		104 S.F.
Spring House		752 S.F.

1. Structures listed in the 100-year floodplain column are also included under PMF.
* Historic

As in alternative B, all the above facilities would be protected to the 100-year flood level but subject to damage from the PMF. The replacement cost for these facilities would be $3,521,500. Flood mitigation costs would be $2,854,500 for structural mitigation and between $90,000 and $205,500 for nonstructural mitigation.

As in alternative A if the option to protect the Cafe to the PMF were selected structural flood mitigation costs would increase by $25,500 to $2,880,000 and replacement costs for property losses would decrease by $1,310,500 to $2,211,000.

CUMULATIVE ENVIRONMENTAL CONSEQUENCES

This section consists of seven charts. Each chart covers an impact topic and summarizes the effects of all the flood mitigation measures employed at all eight areas on that particular impact topic.

CUMULATIVE IMPACTS ON SOILS (Acres of Disturbance)

Areas	No Action	Alternative A (preferred) New Disturbance	Alternative A (preferred) Previous Disturbance	Alternative B New Disturbance	Alternative B Previous Disturbance	Alternative C New Disturbance	Alternative C Previous Disturbance
Mesquite Spring	0	0	0	0	0.1	-	-
Stovepipe Wells	0	3.6	1	-	-	-	-
Emigrant Ranger Station	0	0	0	2.9	0.1	3.9	01
Wildrose Canyon	0	3-4	0	0.5-1	0	-	-
Cow Creek Area	0	0	1	0	0	-	-
Furnace Creek Area Headquarters Wash	0	1.5	0	0	0	-	-
Furnace Creek Wash and Fan	0	2.64	1.01	4.94	1.13	16.38	1.16
Scotty's Castle	0	0	1.6-1.7	0	2.8	-	3.9
Totals	0	10.74-11.74	4.61-4.71	7.34-8.84	4.13	20.28	5.16

	Alternative D New Disturbance	Alternative D Previous Disturbance	Alternative E New Disturbance	Alternative E Previous Disturbance
Mesquite Spring	-	-	-	-
Stovepipe Wells	-	-	-	-
Emigrant Ranger Station	4.9	0.1	0	0
Wildrose Canyon	-	-	-	-
Cow Creek Area	-	-	-	-
Furnace Creek Area Headquarters Wash	-	-	-	-
Furnace Creek Wash and Fan	7.58	1.16	-	-
Scotty's Castle	-	3.4	-	-
Totals	12.48	4.66	0	0

Cumulative IMPACTS ON SCENIC QUALITY[1] (Facilities Affected)

Areas	No Action	Alternative A	Alternative B	Alternative C	Alternative D	Alternative E
Mesquite Spring	0	0	0	-	-	-
Stovepipe Wells	0	1 dike in	-	-	-	-
Emigrant Ranger Station	0	0	2 dikes in	1 submerged dike in 1 dike in	2 dikes in	-
Wildrose Canyon	0	0	0	-	-	-
Cow Creek Area	0	0	0	-	-	-
Furnace Creek Area Headquarters Wash	0	2 dikes in	Rain gauges out	-	-	-
Furnace Creek Wash and Fan	0	2 dikes out 1 large dike out	2 dikes out 1 large dike out	2 high dikes out 1 large dike out 1 large channel out	2 dikes out 1 large dike out 1 large channel out	
Scotty's Castle	0	1 large dike in 1 dike in 1 wall in 4 culverts in	1 underground culvert 1 wall	1 underground culvert	1 underground culvert 1 wall	
Totals	0	4 dikes in 1 large dike out 1 large dike in 1 wall in 4 culverts in	2 dikes in Rain gauges out 2 dikes out 1 large dike out 1 underground culvert 1 wall	1 submerged dike in 1 dike in 2 high dikes out 1 large dike out 1 large channel out 1 underground culvert	2 dikes in 2 dikes out 1 large dike out 1 large channel out 1 underground culvert 1 wall	

[1]Unless otherwise noted, all diversion dikes will be constructed of natural materials to limit visual intrusion, and will in effect constitute minimal visual intrusions.

In = Within existing developed or previously disturbed area.
Out = Outside existing developed or previously disturbed area.

CUMULATIVE IMPACTS ON NATURAL AND BENEFICIAL VALUES OF FLOODPLAINS (Acreage of natural floodplain altered unless otherwise noted)

Areas	No Action	Alternative A	Alternative B	Alternative C	Alternative D	Alternative E
Mesquite Spring	0	0	0	-	-	-
Stovepipe Wells	5-10	5-10	-	-	-	-
Emigrant Ranger Station	1-2	1-2	3-5	3-5	5-7	0
Wildrose Canyon	.5	1.5-2	.5	-	-	-
Cow Creek Area	0	0	0	-	-	-
Furnace Creek Area Headquarters Wash	0	10-20 removed from floodplain	0	-	-	-
Furnace Creek Wash and Fan	0/8-10 sq. mi.	17-23/8-10 sq. mi.	20-30/8-10 sq. mi.	32-42	22-23/8-10 sq. mi.*	-
Scotty's Castle	0	15-20	10-15	15-20	10-15	-
Totals	6.5-12.5/ 8-10 sq. mi.	49.5-78/ 8-10 sq. mi.	33.5-48.5/ 8-10 sq. mi.	54-71	37-45/8-10 sq. mi.*	0

*Partially returned to natural conditions

Cumulative IMPACTS ON RARE, THREATENED, ENDANGERED, OR ENDEMIC SPECIES THAT COULD BE AFFECTED BY STRUCTURAL FLOOD MITIGATION MEASURES

Plant Names	Areas Affected	Category	USFWS Class	Known Endemic Acres	Habitat No Action	Alt. A	Alt. B	Alt. C	Alt. D	Alt. E
Centaurium namophilum	Furnace Creek	I	III	810	0	2-3	5-7	16-20	7-10	-
Enceliopsis cove	Wildrose Furnace Creek	I	II	8,480	0	5-7	5-7	16-20	7-10	-
Astragalus funereus	Wildrose	II	II	8,530	0	3-4	0	0	0	-
Eriogonum eremicola	Wildrose	II	II	3,040	0	3-4	0	0	0	-
Gilmania luteola	Furnace Creek	II	I	14,880	0	2-3	5-7	16-20	7-10	-
Petalonyx thurberi gilman	Headquarters	II	I	13,420	0	1.5	0	0	0	-
Arctomecon merriamii	Stovepipe Wells	III-C	III	17,800	0	5.6-5.7	2.8	3.9	3.4	-
Salvia funerea	Stovepipe Wells	III-C	II	8,460	0	4	0	0	0	-
Boerhaavia annulata	Furnace Creek		II	41,380	0	7.6-8.7	7.8-9.8	19.9-23.9	10.4-13.4	-
Camissonia cardiophylla robusta	Furnace Creek		II	12,830	0	2-3	5-7	16-20	7-10	-
Camissonia claviformis funerea	Stovepipe Wells Furnace Creek		II	30,760	0	7.6-8.7	7.8-9.8	19.9-23.9	10.4-13.4	-
Eriogonum rixfordii	Wildrose		II	7,650	0	3-4	0	0	0	-
Mentzelia reflexa	Furnace Creek		III	15,040	0	2-3	5-7	16-20	7-10	-
Nama demissiim cove	Furnace Creek		II	12,640	0	2-3	5-7	16-20	7-10	-
Oxystylis lutea	Furnace Creek		III	10,430	0	2-3	5-7	16-20	7-10	-
Viguiera reticulata	Stovepipe Wells Wildrose		II	24,620	0	7-8	0	0	0	-

CUMULATIVE IMPACTS ON HISTORIC RESOURCES LEFT UNPROTECTED IN THE FLOODPLAIN

Areas	No Action	Alternative A	Alternative B	Alternative C	Alternative D	Alternative E
Mesquite Spring	0	0	0	-	-	-
Stovepipe Wells	0	0	-	-	-	-
Emigrant Ranger Station	Comfort station Ranger station	Same as No Action	Comfort station Ranger station unprotected for PMF	Same as B	0	0
Wildrose Canyon	CCC-era shed in maintenance area	0	CCC-era shed unprotected for a 100-year flood or PMF	-	-	-
Cow Creek Area	0	0	0	-	-	-
Furnace Creek Area Headquarters Wash	0	0	0	-	-	-
Furnace Creek Wash and Fan	0	0	0	0	0	-
Scotty's Castle	6 structures	2 structure unprotected for PMF	6 structures unprotected for PMF	0	6 structures unprotected for PMF	- 0
Totals	9 structures	4 structures	9 structures	2 structures	6 structures	0

CUMULATIVE IMPACTS ON PUBLIC SAFETY (People without structural protection in the PMF)

Areas	No Action		Alternative A		Alternative B		Alternative C		Alternative D		Alternative E	
	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night
Mesquite Spring	7	70	7*	70*	0	0	-	-	-	-	-	-
Stovepipe Wells	300	650	0	0	-	-	-	-	-	-	-	-
Emigrant Ranger Station	10	35	10	0	10	0	10	0	0	0	0	0
Wildrose Canyon	6	45	0	0	6	0	-	-	-	-	-	-
Cow Creek Area	45	33	0	0	45	33	-	-	-	-	-	-
Furnace Creek Area Headquarters Wash	1,000	3,500	0	0	1,000	3,500	-	-	-	-	-	-
Scotty's Castle	270	10	-	-	270	10	0	0	270	10	-	-
Furnace Creek Wash and Fan	40	90	5	0	5	0	5	0	5	0	-	-
Total	1,408	4,423	22	70	1,366	3,543	15	0	275	10	0	0

*On only 2-3 weekends per year when these sites would be occupied in the low flood hazard season

CUMULATIVE IMPACTS ON PUBLIC PROPERTY (Replacement Costs of Property left unprotected in the 100-year and PMF floodplains/flood mitigation Cost)

Area	No Action 100-Year	No Action PMF	No Action Mitigation	Alternative A 100-Year	Alternative A PMF	Alternative A Mitigation	Alternative B 100-Year	Alternative B PMF	Alternative B Mitigation
Mesquite Spring	$ 36,000	$ 8,000	0	$ 36,000	$ 8,000	$ 10,000	$ 4,000	$ -	$ 49,500
Stovepipe Wells	12,023,000	-	0	0	-	427,500-460,500	-	-	-
Emigrant Ranger Station	451,500	-	0	332,000	-	425,500-486,000	0	404,500	502,000
Wildrose Canyon	621,000	-	0	0	-	713,000	621,000	-	408,500-416,500
Cow Creek Area	723,000	-	0	0	-	31,500-263,000	723,000	-	0
Furnace Creek Area/ Headquarters Wash	5,064,500	-	0	0	-	301,500	5,064,500	-	50,500-211,500
Furnace Creek Wash and Fan	0	6,382,500	0	0	1,587,500	641,500-794,500	0	1,587,000	576,500-584,000
Scotty's Castle	447,500	3,521,500	0	63,000	2,111,000-3,409,500	648,000-789,000	0	2,111,000-3,521,500	3,145,000-3,286,500
Total	$19,366,500	$9,912,000	0	$431,800	$3,706,500-5,005,000	$3,198,500-$3,817,500	$6,412,500	$4,103,800-5,514,300	$4,732,000-$5,050,000

Area	No Action 100-Year	No Action PMF	No Action Mitigation	Alternative C 100-Year	Alternative C PMF	Alternative C Mitigation	Alternative D 100-Year	Alternative D PMF	Alternative D Mitigation
Mesquite Spring	-	-	-	-	-	-	-	-	-
Stovepipe Wells	-	-	-	-	-	-	-	-	-
Emigrant Ranger Station	0	$ 404,500	$ 643,500	0	-	$ 566,500	0	0	$451,500
Wildrose Canyon	-	-	-	-	-	-	-	-	-
Cow Creek Area	-	-	-	-	-	-	-	-	-
Furnace Creek Area/ Headquarters Wash	-	-	-	-	-	-	-	-	-
Furnace Creek Wash and Fan	0	1,587,500	8,011,000-8,164,000	0	1,587,500	3,630,000-3,637,500	-	-	-
Scotty's Castle	0	0	5,977,000	0	2,111,000-3,521,500	2,944,500-3,085,500	-	-	-
Total	0	$1,992,000	$14,627,500-$14,680,500	0	$3,698,500-$5,109,000	$7,141,000-$7,289,500	0	0	$451,500

REFERENCES AND APPENDIXES

REFERENCES

U.S. GEOLOGICAL SURVEY STUDIES

Bowers, James C. 1983. Potential Hazards From Floodflows in Grapevine Canyon, Death National Monument, California and Nevada. Water Resources Investigations Report. Sacramento, Ca.

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Brunson, R.F., T. Gorden, and R. Greslin. 1985b. Structural Mitigation, Death Valley Flood Studies, Volume II. Unpublished Engineering Report, Denver Service Center.

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APPENDIX A
FLOODPLAIN AND WETLAND COMPLIANCE

Executive order 11988 was developed "in order to avoid to the extent possible the long and short term adverse impacts associated with the occupancy and modification of floodplains and to avoid direct ar indirect support of floodplain development wherever there is a practicable alternative." (E.O. 11988; 42 FR 2691)

National Park Service Floodplain management and Wetland Protection Guidelines (Federal Register/Vol. 45, No. 104/ May 28, 1980) list procedures for complying with the executive order. These procedures require identification of floodplain, flood hazard and wetland areas potentially subject to public use and/or development, where the magnitude of hazard and impact of human activities is likely to be greatest; determination if the proposed action is in or could affect a floodplain or wetland; public review; identification and evaluation of practicable alternatives to locating in the base floodplain or wetland; identification of impacts; minimization of impacts; restoration, preservation and enhancement of floodplain values; and findings and public explanation.

During development of the General Management Plan (GMP), 100-year floodplains, Probable Maximum Floodplains, Flood Hazard areas and wetlands within Death Valley National Monument were identified. Input was obtained from the public in the development of alternatives and facilities that would remain in the floodplain and flood hazard areas are identified and estimates are provided for numbers of people expected to be in the floodplain. The alternatives consider removing development in some areas from the floodplain. Impacts on natural and beneficial values of desert springs and floodplains were analyzed in the GMP's EIS and the assessment accompanying the April, 1988 study. The planning team has located no new developed areas in flash floodplains. Therefore, the plan already exhibits compliance with most of the requirements of the Executive Order and implementing guides. All that remains to be done to complete the complaince process is public review of this assessment; and development and approval of a Statement of Findings. The Statement of Findings will be prepared following public review of this document.

The steps required for public review are: Treat the issue in an environmental document that complies with public involvement requirements of CEQ; provide public notice to individuals and groups affected by, or with a direct interest in, the proposed action and allow them to assist in development of alternatives; circulate NEPA and decision documents to at least the following:

EPA
Federal Emergency Management Agency
U.S. Fish and Wildlife Service
U.S. Geological Survey
Water and Power Resources Service (Bureau of Reclamation)
U.S. Army Corps of Engineers
U.S. Soil Conservation Service
State and area Clearinghouses
Costal or River Basin Commissions and State Costal Zone
Management Administrations as appropriate;

make the assessment available for public and agency comment for a minimum of 60 days from the date it is filed with the EPA; indicate in the Federal Register notice of availability and on the Cover sheet of the assessment that the assessment is also to serve as a compliance instrument for the orders; include above agencies in distribution of the assessment.

APPENDIX B
WARNING SYSTEM CALCULATIONS

100-yr flood CFS	30 min Precipitation		Storm Cell Size sq. mi.	Drainage Size sq. mi.	# Guages	Approximate Flood Velocity MPH	
	100-yr	PMP				100-yr	PMF
Scotty's Castle							
8,500	.73	--	4.5	30	8	9	--
8,500	--	2.85	1.2	30	25	--	14
Emigrant Ranger Station							
9,375	.67	--	5.4	70	13	6	--
9,375	--	3.11	1.3	70	42	--	15
Wildrose							
10,200	1.6	--	2.5	24	10	14	--
10,200	--	3.1	1.3	24	19	--	30
Headquarters Wash							
2,400	.78	--	1.2	6	5	8	--
2,400	--	3.97	.23	6	26	--	10
Furnace Creek Wash							
27,000	.67	--	15.6	228	15	10	--
27,000	--	2.07	5.1	228	45	--	19

This method for deriving the needed number of rainfall gauges is adapted from the 1985 unpublished draft report for Lake Mead National Recreation Area by Jim Owen and Ben Roberts of Flood Loss Reducation Associates. The question being asked is -- what is the smallest storm cell that would produce the 100-yr flood, and therefore how many rainfall gauges would be needed to be assured of monitoring that storm cell within the given drainage. The storm cell size is calculated using the 100-yr flood and 30 min precipitation (100-yr or probable maximum) to arrive at the number of gauges needed, then the drainage is divided by the storm cell size. Approximate velocities of flood flows are shown because they were used to determine warning times for stream gauge systems.

APPENDIX C: DEVELOPMENT WITHIN FLOODPLAINS

Table C1. Development in the 100-Year and Probable Maximum Floodplains (PMF)

Development	Existing Conditions/Structure[1]	
	100-Year	PMF
Scotty's Castle Area		
Services and Lodging		
Dining Room and Curio Shop		8,119 S.F.
Restroom (historic)		528 S.F.
Stables (historic)		10,504 S.F.
Service Station Building	36 S.F.	
Ticket Office		80 S.F.
Housing		
Bridge Apartment (historic)	578 S.F.	
Utilities		
Storage Building		180 S.F.
Chlorinator House	104 S.F.	
Spring House	752 S.F.	

1. Structures listed in the 100-year floodplain column are also included under PMF.

Table C.2 Estimated Cost[1] of Facility Replacement from 100-Year and Probable Maximum Flood (PMF)

Developed Area	100-Year	PMF
Scotty's Castle	$447,500	$3,521,500

1. Site development cost (20%) is included in the total cost estimate for each area. Costs for roads, parking, walkways, open storage areas, utilities, and picnic areas are not included.

APPENDIX D
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